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Hedging the Fishy Fishmeal Prices

An investigation into the viability of a potential fishmeal futures contract

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Abstract

Salmon futures contracts have existed for more than a decade, and futures contracts for aquaculture feed ingredients such as corn, soybean meal and wheat have existed much longer. Fishmeal is also a key feed ingredient, and its industry has been argued to be one of the most volatile business environments of the food sector. Yet, efforts to establish a futures contract for fishmeal have not been seen.

This thesis investigates the viability of a potential fishmeal futures contract, based on success factors for futures contracts identified by the literature. To do so, we conduct both quantitative and qualitative analysis. We utilise data on fishmeal prices and production statistics, in addition to prices and trading volumes of soybean meal and corn futures, between 2005 and 2017.

The quantitative analysis consists of two separate approaches. First, we conduct a cointegration analysis to investigate whether fishmeal is homogenous and whether it has one or more markets. Second, as a proxy for futures contract success, we apply an empirical model developed by Bekkerman and Tejeda (2017) to predict the probability of a fishmeal futures contract already existing. To obtain estimates for variables included in this model, we conduct a survey of industry experts on fishmeal, in addition to empirically estimate and collect measures. The qualitative analysis takes into consideration the quantitative results and provides a thorough, more nuanced discussion of the viability of a fishmeal futures contract.

The cointegration analysis indicates the existence of one fishmeal submarket in the Nordics and one in South America, and that fishmeal may be homogenous only within these submarkets. The model of Bekkerman and Tejeda (2017) predicts a zero percent probability of a fishmeal futures contract already existing. The qualitative analysis reveals that price risk, homogeneity, market size, storability, and lack of relevant and efficient cross-hedging alternatives speak in favour of the viability of a fishmeal futures contract. Optimal contract design can somewhat overcome identified issues, but the existence of market power, vertical integration and lack of transparency are assessed to outweigh the favourable characteristics. Therefore, we conclude that a fishmeal futures contract, under current market conditions, is not viable.

Preface

The completion of this thesis concludes our Master of Science in Financial Economics at the Norwegian School of Economics (NHH). The research and writing of this thesis have been conducted in the spring semester of 2018, and have been a challenging and difficult, but above all enjoyable, educational and rewarding experience.

We would like to express our gratitude to everyone who has guided, contributed and motivated us throughout this semester. Without them, there would be no master thesis. First, we would like to thank our supervisor Petter Bjerksund, for providing us with his guidance and invaluable feedback. Second, we would like to thank Alexander Sherling at Norsildmel for providing us with an understanding of the fishmeal industry, and for answering any questions that we have had about the industry throughout the semester. Third, we would like to thank Dr. Enrico Bachis at IFFO – The Marine Ingredients Organisation for providing us with data, insights about the fishmeal industry, and for introducing us to decision-makers in the industry. Fourth, we would like to thank Magnus Strand at Pelagia for valuable feedback and guidance regarding our topic. Fifth, we would like to thank Øivind Anti Nilsen at NHH for his guidance regarding econometric techniques and theory. Finally, we would like to thank our expert survey panel who gave us valuable insights about the fishmeal market: Frank Asche (University of Stavanger), Geir Småvik (Marine Harvest), Hans de Wit (Köster Marine Protein), Jon Tarlebø (Norsildmel), José Rainuzzo (TASA), Niels Alsted (Biomar Group) and Sigbjørn Tveterås (University of Stavanger).

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1. Introduction

In Subchapter 1.1, our motivation and the problem to be addressed will be presented. Subchapter 1.2 will present the method utilised to investigate the problem, and the structure of the thesis.

1.1 Motivation and Problem to be Addressed

The aquaculture industry has grown substantially during the last decades, and so has the attention it receives. Fisheries receive comparatively less attention, and we have found pelagic fisheries to be particularly under-analysed. The lack of attention has triggered our interest in it.

Conversations with people in the industry revealed that price fluctuations are commonplace in pelagic fisheries, but that futures contracts are absent. At first, we considered researching the viability of a futures contract for a specific pelagic species. However, with time and some guidance, the price volatility and favourable traits of fishmeal convinced us that this was perhaps a more ideal candidate. As Rabobank Senior Analyst Gorjan Nikolik puts it: The fishmeal market is "… one of the most volatile business environments of the food sector" (Villegas, 2015, para. 25).

The global fishmeal industry is geographically fragmented, with production mainly located in South America, the Nordics, and parts of Asia. While supply of raw material is limited, demand for fishmeal from feed producers is expected to continue an upward trend. As a result, fishmeal prices have increased substantially in recent decades, but supply shocks still leave industry participants vulnerable to considerable price risk. While many companies are vertically integrated, and uncleared forward contracting is commonplace, participants both in and outside the fishmeal industry lack the opportunity to utilise futures contracts for hedging or speculation purposes.

The potential benefits of introducing a fishmeal futures contract are several. Introducing a futures contract would make it possible for fishmeal companies to transfer the price risk to others who are willing to accept it (Pennings, 1999). Commercial participants would get the opportunity to achieve more predictable revenues or costs, while speculators would be able to bet on price changes. In addition to facilitating this transfer of risk, which could also help commercial participants secure cheaper financing, futures contracting would eliminate the counterparty risk associated with the forward contracting which is utilised in the industry today. Further, a futures contract would increase price transparency, which would be positive in terms of both planning and forecasting. This could in turn lead to less volatile prices.

Our conversations with people in the fishmeal industry revealed that the interest in a futures contract has been, and still is, substantial. Consequently, the problem to be addressed in this thesis is whether a fishmeal futures contract is viable. The findings should be of interest to both commercial players, industry organisations, and futures exchanges that consider introducing new contracts.

1.2 Method and Thesis Structure

To investigate whether a potential fishmeal futures contract is viable, we conduct both a quantitative and a qualitative analysis. In these analyses, data on fishmeal from Peru, Chile, Iceland and Denmark, and global fishmeal production statistics, between 2005 and 2017 are utilised. Prices and trading volumes of soybean meal and corn futures contracts listed on the Chicago Board of Trade for the corresponding time period are also subject to analysis. Due to restricted availability of data, the main focus of this thesis is on fishmeal of Nordic and South American origin.

The quantitative analysis consists of two separate approaches: a cointegration analysis and the employment of an empirical model developed by Bekkerman and Tejeda (2017) on fishmeal. The cointegration analysis is conducted to clarify whether fishmeal is a homogenous commodity, and whether it has one or more separate markets. The model developed by Bekkerman and Tejeda (2017) predicts the probability of there existing a futures contract for a given agricultural commodity, and the model is utilised in this thesis as a proxy for futures contract success. To predict the probability in this model, a survey of industry experts on fishmeal are conducted to estimate some of the variable measures.

The qualitative analysis takes into consideration the results from the quantitative analyses, and provides a nuanced, thorough discussion of success factors identified by the literature as important for the success of futures contracts. Key literary contributions to the topic are, among others, Bekkerman and Tejeda (2017), Bergfjord (2007), Black (1986), and Brorsen and Fofana (2001). The discussion evolves around aspects related to the underlying commodity market and other futures markets, the exchange introducing the contract and the users of it, and optimal futures contract design. Our analyses reveal that several factors speak in favour of a potential fishmeal futures contract. However, due to problems related to vertical integration, market power and lack of transparency, we finally conclude that a potential fishmeal futures contract, under current market conditions, is not viable.

To provide the reader with context, **Chapter 2** presents an overview of fishmeal and its market. **Chapter 3** presents the key factors and aspects important for futures contract success identified by the literature. **Chapter 4** presents the data, theory and methodology applied in the quantitative analysis, as well as an overview of the methodological approach in this thesis. Empirical results are presented in **Chapter 5**. This chapter also includes initial implications of the results. A more thorough discussion of the empirical results and the qualitative analysis follow in **Chapter 6**.

Chapter 7 summarises key takeaways from the thesis and provides the reader with a conclusion. Finally, **Chapter 8** highlights weaknesses and limitations of this thesis, and suggests topics for future research.

2. The Fishmeal Market

For reference and information to the reader, Chapter 2 will provide a brief overview of fishmeal and its market. Subchapter 2.1 will cover the characteristics of fishmeal as a commodity, while Subchapter 2.2 will cover the market characteristics.

2.1 Fishmeal Characteristics

Fishmeal, a brown coloured flour, is obtained after cooking, pressing, drying and milling whole fish and fish by-products. The whole fish used in fishmeal production is predominantly small, bony pelagic fish species known as forage fish (Fishmeal Information Network (FIN), 2008). Examples of forage fish utilised as raw material in fishmeal production are Anchoveta, Horse mackerel, Sandeel, Capelin and Menhaden (IFFO - The Marine Ingredients Organisation [IFFO], 2017a). Fish by-products, stemming from either low-fat white-fish or oily fish such as Herring and Mackerel, are now constituting around 25-35% of input in global fishmeal production (IFFO - The Marine Ingredients Organisation [IFFO], 2017b; Seafish, 2016).

Fishmeal typically contains 60-72% protein, 10-20% ash and 5-12% fat (IFFO, 2017a). The fat has a high content of the long-chained polyunsaturated fat acids EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), also known as Omega-3s (IFFO, 2017a). Fishmeal products are graded according to protein concentration, and there are three main fishmeal grades marketed globally (Sherling, 2018):

1. Super Prime Fishmeal – 68% protein concentration
2. Prime Fishmeal – 67% protein concentration
3. Standard or FAQ (Fair Average Quality) Fishmeal – 65% protein concentration

In addition to the three main grades, which are mainly produced in South America, there are also variations of Super Prime Plus Fishmeal marketed, mainly produced in Nordic countries. Icelandic, Norwegian and Danish producers are mainly producing fishmeal with 70-72% protein concentration (Sherling, 2018).

2.2 Market Characteristics

In this subchapter, an overview of fishmeal supply, demand and price development will be presented.

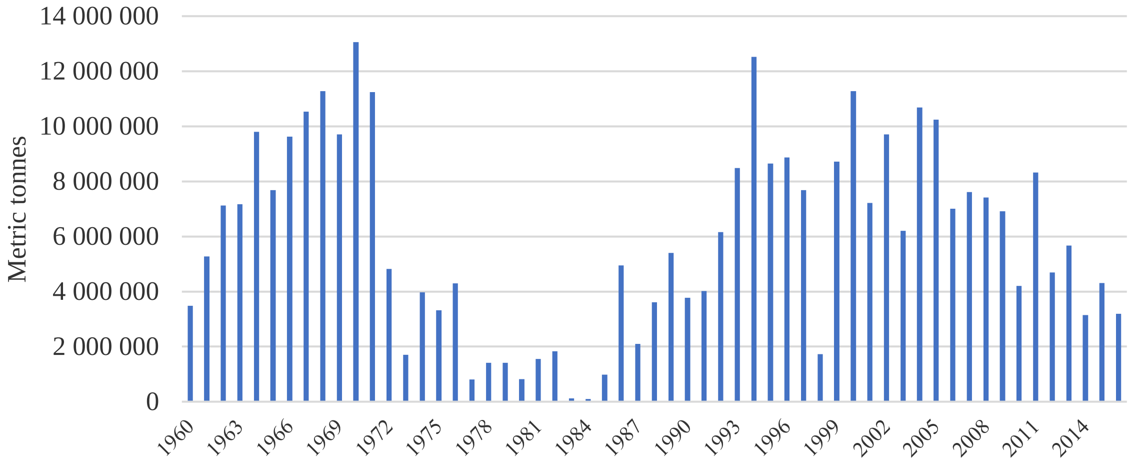
2.2.1 Supply of Fishmeal

Raw Materials

In the 2008-2012 period, it is estimated that approximately 16-20% of global capture fisheries production was reduced to fishmeal either directly through whole fish input or indirectly through fish by-products (FAO, 2014). The share of global capture fisheries production reduced to fishmeal is, however, declining due to increased human consumption, tighter quotas, additional controls on unregulated fisheries and an increased effort to replace whole fish with fish by-products as input factors (Seafish, 2016). Fish destined for reduction peaked in 1994 at 30.2 million tonnes and has since dropped to 16.3 million tonnes in 2012 (FAO, 2014). Due to global increased focus on sustainability and biological limits, global capture fisheries are not expected to grow, and thus the use of whole fish in fishmeal production is effectively capped. The only potential for raw material growth, although small relative to existing production volume, is to increase the use of fish by-products.

Forage fish is the main raw material source in fishmeal production, and Anchoveta, also known as Peruvian anchovy, is undecidedly the largest input factor (Seafish, 2016). Anchoveta is the most exploited fish species in history, but the schools residing off the Peruvian and Chilean coast are very sensitive to the El Niño weather phenomenon (FAO, 2018a). The El Niño weather phenomenon, occurring irregularly every two to seven years, leads to increased water surface temperatures, which in turn stops the upwelling of nutrient-rich cold water (National Geographic Society, 2018). The Anchoveta schools depend on the natural upwelling process for food, and the occurrence of the El Niño phenomenon, depending on severity, can lead to mass migration or population collapses (National Geographic Society, 2018). Comparing Figure 1 and Table 1, one can see a clear coinciding of occurrences of the El Niño weather phenomenon and low Anchoveta capture production, especially in the seasons of 1982-83, 1997-98 and 2015-16 where the phenomenon was categorised as “very strong”, but also in the greater part of the 1970’s which was plagued by several “weak” phenomena. Due to the volatile capture production of Anchoveta, supply of raw material for reduction to fishmeal has been, and will continue to be, very volatile.

Figure 1: Anchoveta Capture Production, 1960-2016



Source: FAO (2018b)

Table 1: Overview of Occurrences of El Niño, 1950-2018

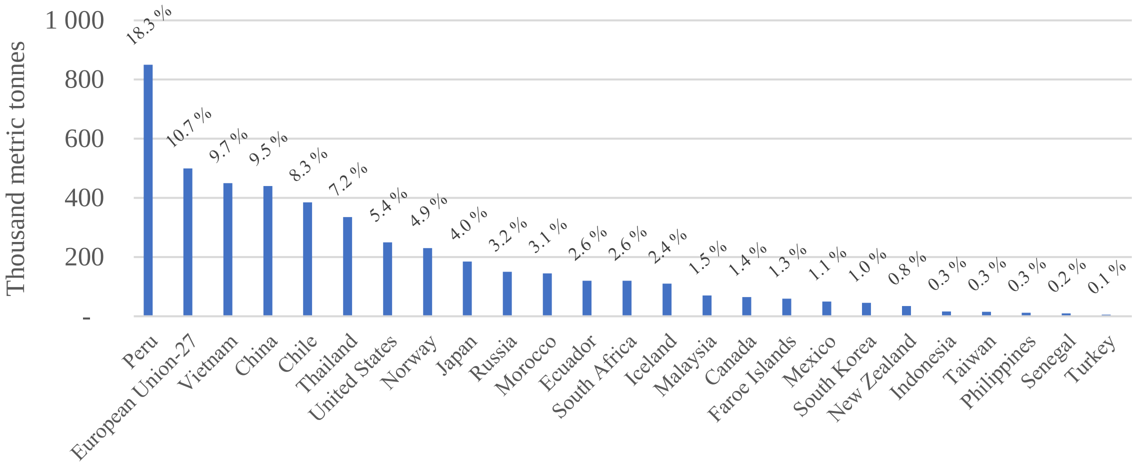
Weak	Moderate	Strong	Very strong
1952-53	1951-52	1957-58	1982-83
1953-54	1963-64	1965-66	1997-98
1958-59	1968-69	1972-73	2015-16
1969-70	1986-87	1987-88	
1976-77	1994-95	1991-92	
1977-78	2002-03		
1979-80	2009-10		
2004-05			
2006-07			
2014-15			

Source: Null (2018)

Production of Fishmeal

Production of fishmeal is predominantly happening in the proximity of areas in which raw material is harvested. The large Anchoveta population in the Pacific Ocean makes Peru the single largest fishmeal producing country, with an estimated 18.3% share of global production in 2017 (United States Department of Agriculture [USDA], 2018). Chile, utilising the same Anchoveta species, is also a large producer with an estimated 8.3% share of production in 2017 (USDA, 2018). Asian countries such as Vietnam, China, and Thailand, as well as countries situated around the Norwegian Sea and the North Sea such as Denmark, Iceland, the Faroe Islands, the UK, and Norway, are also important fishmeal producing countries (USDA, 2018). The geographic distribution of fishmeal production globally in 2017 is shown in Figure 2.

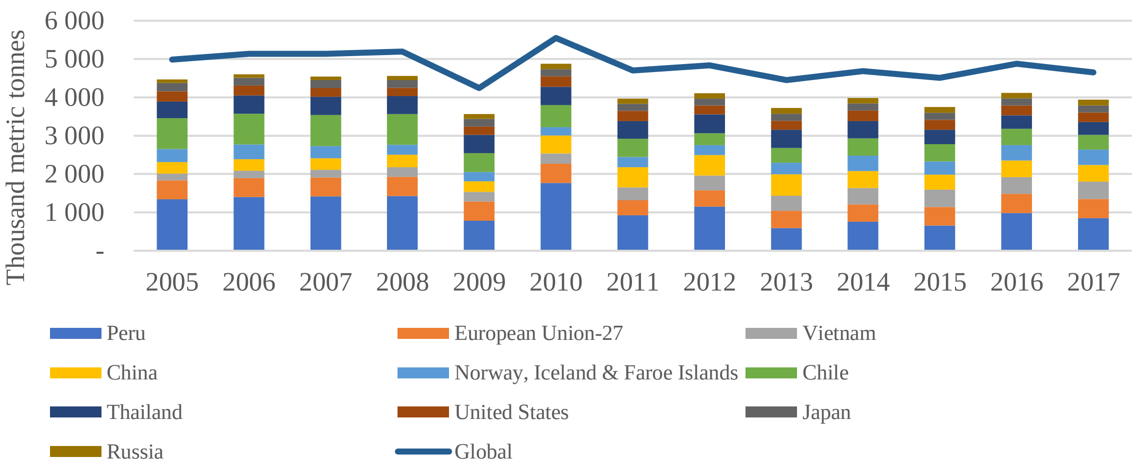
Figure 2: Production and Share of Global Production for Fishmeal Producing Countries, 2017



Source: USDA (2018)

Due to yearly and seasonally large swings in Peruvian and Chilean Anchoveta capture production, and the importance of this species as input factor, global fishmeal production has experienced large swings over the years, with highs of 5.6 million tonnes in 2010 and lows of 4.2 million tonnes in 2009 in the 2005-2017 period. Despite fluctuations from season to season, global fishmeal production has oscillated around 5 million tonnes in recent years (USDA, 2018). The development in the global fishmeal production and the share of the top ten producing countries is shown in Figure 3.

Figure 3: Global Production and Production of Top Ten Fishmeal Producing Countries, 2005-2017



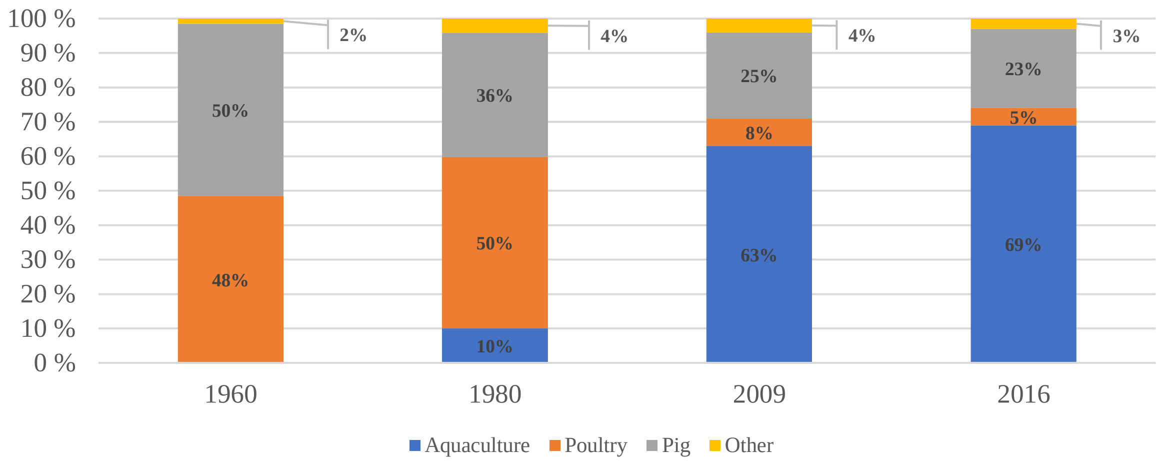
Source: USDA (2018)

2.2.2 Demand for Fishmeal

Fishmeal has always been an important feed ingredient, and it is currently being utilised in both the aquaculture, land animal farming and pet food industries (IFFO, 2017b). In recent decades, fishmeal has almost entirely shifted from being utilised in its traditional markets – poultry and pig feed – to being utilised as a key feed ingredient in the aquaculture industry due to its unique characteristics (Asche, 2016). The aquaculture industry especially appreciates the superior growth performance, reduced mortality, palatability and increased consumer acceptance that the use of fishmeal in feed offers (Asche, Øglend, & Tveterås, 2013).

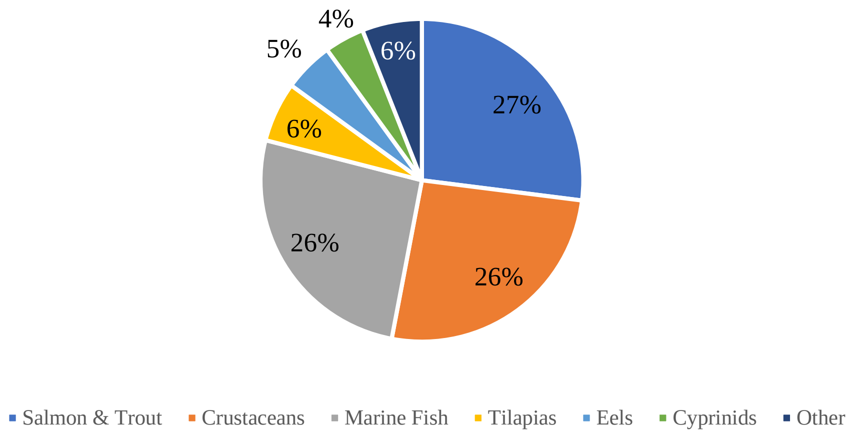
Development in end market usage for fishmeal and in usage within the aquaculture feed industry are shown in Figure 4 and Figure 5 and 6**,** respectively.

Figure 4: Percentage of Fishmeal Usage per Market 1960, 1980, 2009 and 2016



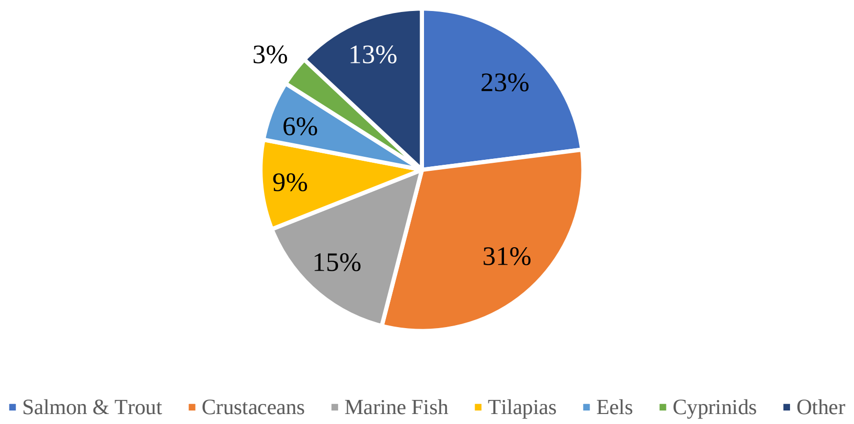
Source: Auchterlonie (2018) *and Sheperd* (2011)

Figure 5: Share of Fishmeal End-Usage by Species in Aquaculture 2009



Source: Auchterlonie (2018) *and Sheperd* (2011)

Figure 6: Share of Fishmeal End-Usage by Species in Aquaculture 2016

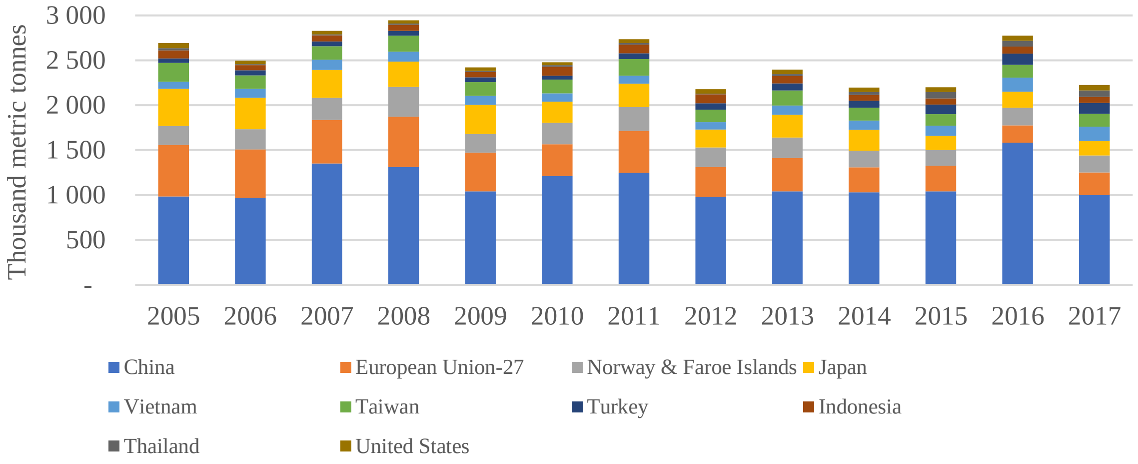


Source: Auchterlonie (2018) *and Sheperd* (2011)

According to OECD and FAO, aquaculture surpassed wild fish captures as the major contributor to global fish food supply in 2014 (OECD/FAO, 2016). Aquaculture production is expected to grow at an estimated annual growth rate of 3.0%, and most of the growth is expected to be seen in developing countries, particularly in Asia (OECD/FAO, 2016). With a relatively constant supply of fishmeal, and the explosive growth seen in aquaculture in recent decades, inclusion rates of fishmeal in aquaculture feed have been forced down. The decline of fishmeal and fish oil inclusion in salmon feed from approximately 69% in the 1990's to approximately 31% in 2015 illustrates this (Nikolik, 2015). It is, however, argued that inclusion rates below current levels will become increasingly difficult to reach (Nikolik, 2015).

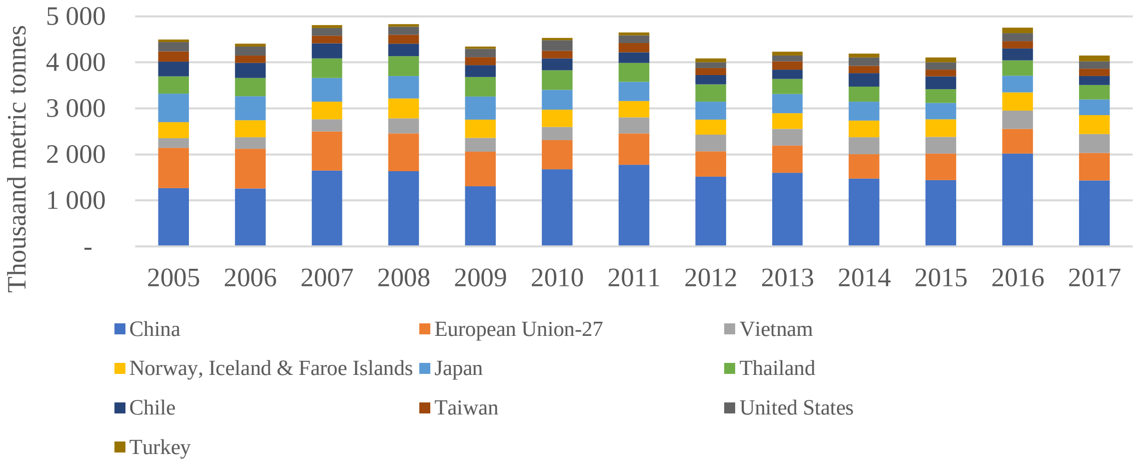
Import and domestic consumption statistics, as presented in Figure 7 and Figure 8, respectively, show both statically and increasingly that demand for fishmeal is coming from leading countries in aquaculture such as China, Vietnam, Norway, Iceland, and the Faroe Islands.

Figure 7: Imports by Top Ten Fishmeal Importing Countries, 2005-2017



Source: USDA (2018)

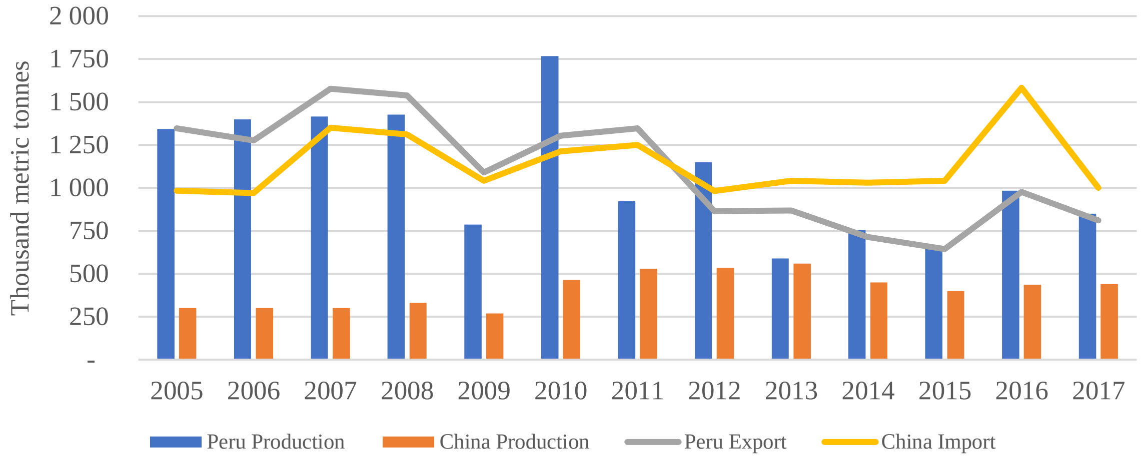
Figure 8: Consumption by Top Ten Fishmeal Domestic Consuming Countries, 2005-2017



Source: USDA (2018)

Aquaculture has experienced rapid growth in China, and accordingly China is the largest fishmeal importing and domestic consuming country while also being the fourth largest fishmeal producing country in the world (USDA, 2018). As illustrated in Figure 9, China's import of fishmeal is equivalent to, and in some years also exceeds, Peru's production and export, and total Chinese domestic consumption is on the rise.

Figure 9: Fishmeal Market Development in Peru and China, 2005-2017



Source: USDA (2018)

2.2.3 Fishmeal Price Development

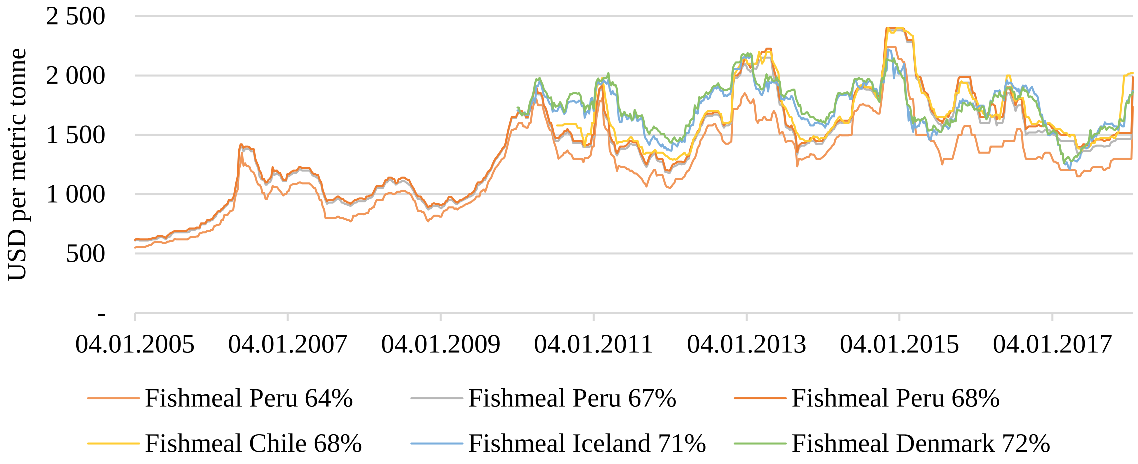
With strong and growing demand for fishmeal from the aquaculture feed industry and an effectively capped supply of raw material, fishmeal prices have experienced a strong increase in recent decades. In Figure 10, weekly fishmeal prices of different protein concentrations of South American and Nordic origin are plotted for the time period 04.01.2005-23.01.2018[1].

Due to the general scarcity of, and volatility in, landing volumes of raw material from season to season (mainly driven by the El Niño weather phenomenon), supply shocks, and corresponding price shocks, are commonplace in the fishmeal industry. Between 2005 and 2017, price volatility, measured by the coefficient of variation, of Peruvian Super Prime Fishmeal was 29.1%[2].

[1] The time period for which price data is available varies for some varieties of fishmeal. The specific time periods covered for each price series are described in detail in Section 4.2.1.

[2] Calculated on price series for Fishmeal Peru 68% (FOB) for the time period 04.01.2005-31.12.2017. The price series is described in detail in Section 4.2.1.

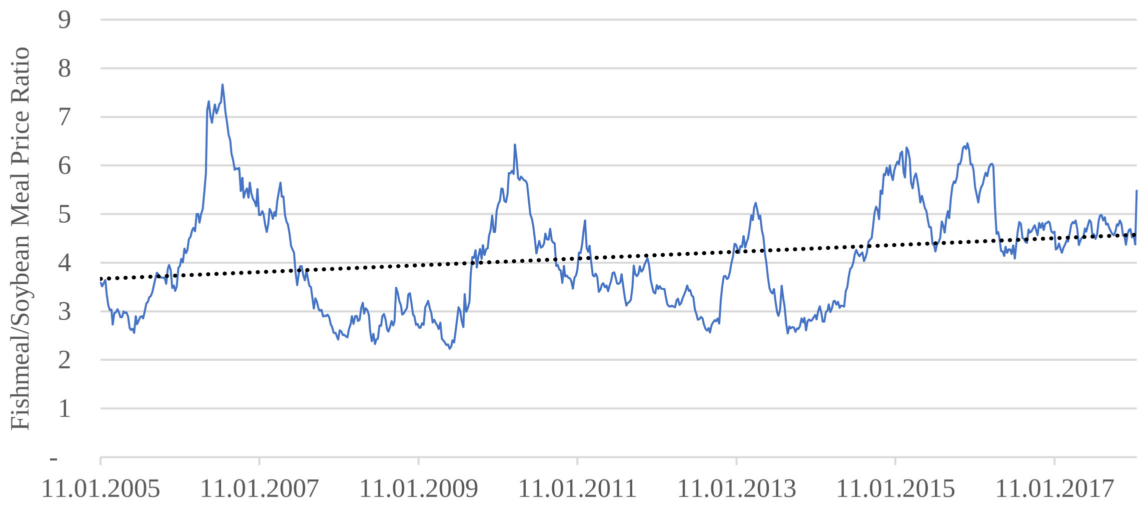
Figure 10: South American and Nordic Fishmeal Prices, 04.01.2005-23.01.2018



Source: IFFO – The Marine Ingredients Organisation

For a long time, there has been strong linkage between prices of fishmeal and soybean meal, as they have been seen as substitute commodities and important ingredients in agricultural and aquaculture feed (Villegas, 2015). Several papers, among them Asche and Tveterås (2004), Gjerde (1989), and Vukina and Anderson (1993) find that soybean meal futures have high hedging efficiency when cross-hedging fishmeal, supporting that, at least in the past, the two commodities have been close substitutes. However, both Kristofferson and Anderson (2006) and Tveterås (2010) find evidence of a structural change in the price ratio of fishmeal and soybean meal that took place around 1998 and that the historical relationship between them has changed. Both further argue that a likely cause of this decoupling is increased demand pressure on fishmeal from industries where it has specialty uses, such as the aquaculture, pig and poultry industries. This hypothesis is supported by Rabobank Senior Analyst Gorjan Nikolik, who states that there no longer is correlation between fishmeal and soybean meal (Villegas, 2015). Asche, Øglend and Tveterås (2013) offers another explanation of this phenomenon, arguing that fishmeal and soybean meal have shifted between two persistent price regimes, where the first regime (pre 1998) was characterised by relative low price ratio volatility and constant unconditional mean price ratio, while the second regime (post 1998) is characterised by higher price ratio volatility and increased and upward trending mean price ratio (where fishmeal is the numerator). All explanations do, however, favour that a structural change has occurred, and that the price ratio between fishmeal and soybean meal has become more volatile, implying that for instance cross-hedging fishmeal with soybean meal futures has become less efficient and that the optimal hedging ratio[3] has become less of a static size. The cash price ratio between Fishmeal Peru 68% and Soybean Meal Brazil for the time period 04.01.2005-23.01.2018 is plotted in Figure 11. The figure suggests an upward trending mean price ratio[4], plotted in dotted line, and large variability in the price ratio is also apparent.

Figure 11: Cash Price Ratio: Fishmeal Peru 68% Protein/Soybean Meal Brazil, 04.01.2005-23.01.2018



Source: IFFO – The Marine Ingredients Organisation

[3] The optimal amount of futures contracts to be held long or short in a hedging strategy.

[4] Not formally tested for.

3. What Makes a Futures Contract Successful?

To determine which factors contribute to the success of a potential futures contract, it is first necessary to define success. Bekkerman and Tejeda (2017), Black (1986), and Brorsen and Fofana (2001) agree that a successful contract is one that maintains a high volume of trade and open interest. This definition will be applied throughout this thesis.

The factors leading to futures contract success have been investigated by several researchers in the past decades. Key factors and aspects will be presented in this chapter, and the viability of a fishmeal futures contracts will later be evaluated in light of these. Comparisons with studies on specific futures markets are made in the discussion in Chapter 6.

In Subchapter 3.1, factors related to the underlying commodity market and other futures markets will be presented. The first eight factors in this subchapter will later be subject to quantitative investigation through a model developed by Bekkerman and Tejeda (2017) and some through the Delphi method[5]. In Subchapter 3.2, theory related to the exchange and its users will be presented. Finally, Subchapter 3.3 will present theoretical aspects related to optimal contract design.

Papers with major contributions to the topic of futures contract success include, among others, Bekkerman and Tejeda (2017), Bergfjord (2007), Black (1986), Brorsen and Fofana (2001), Carlton (1984), Gray (1966), Silber (1981), and Tashjian and Weissman (1995). The factors presented in the following represent those that most researchers have mentioned and seem to agree about.

The success factors can be divided into four groups (Bergfjord, 2007). These groups can be stated as factors related to:

1. The underlying commodity market
2. Other futures contracts
3. The exchange introducing the contract and its potential users
4. The actual contract

[5] The model of Bekkerman and Tejeda (2017) and the Delphi method are explained in Subchapter 4.4.

3.1 Factors Related to the Underlying Commodity Market and Other Futures Markets

In the following, success factors related to the underlying commodity market and other futures markets will be presented. The first eight factors are included in the model of Bekkerman and Tejeda (2017).

1. Uncertainty

Cash price variability is an important success factor for a futures contract (Black, 1986). If there is little uncertainty related to future prices, potential users of a futures contract will have little incentive to trade in it.

Carlton (1984) argues that the uncertainty criteria may be fulfilled also in the case of low price uncertainty. If supply is stochastic, there may still be revenue uncertainty that can make producers interested in participating in a futures market. Of course, the price elasticity will determine whether varying supply will affect prices as well.

2. Size of the Cash Market

The larger is the cash market, the more likely is it that hedgers and speculators will make use of the futures market (Carlton, 1984). Carlton (1984) argues that when the value of all the transactions in the industry is higher, the incentive to invest in prediction will also be higher. Consequently, more players are presumed to take part in the futures market with their knowledge and predictions. Both Bekkerman and Tejeda (2017), Black (1986), and Brorsen and Fofana (2001) empirically find that cash market size has a positive effect on the success of a futures contract.

3. Product Homogeneity or Well-Established Grading System

For a futures contract to be successful, the commodity should be homogenous or gradable with price differences that are well-established (Carlton, 1984). A commodity's futures contract is standardised in terms of units, quality and delivery location. If these characteristics greatly differ, and it is hard to grade the commodity, utilising the futures contract for hedging price risk may not be applicable for large parts of the potential user mass. Still, Black (1986) argues that futures contracts may also be useful to those who deal in the non-standard grade of the commodity if prices of different grades have a close and foreseeable relationship.

4. Activeness of the Cash Market

An active cash market can be interpreted as a market "in which a large number of market participants quote bids and offers daily" (Brorsen & Fofana, 2001, p. 135). An active cash market should attract more hedgers and speculators and lead to a higher volume of trade and open interest (Brorsen & Fofana, 2001). Brorsen and Fofana (2001) finds that the presence of high cash market activity perfectly predicts whether an agricultural commodity has a futures contract and argues that this characteristic is a necessity for a futures contract to be successful. The activeness of the cash market is asserted to be particularly important for a futures contract not already existing, with lower importance once the contract exists. This receives support from Pannel, Hailu, Weersink and Burt (2008) and Simmons (2002).

5. Degree of Vertical Integration

Vertical integration in the spot market of a commodity affects the success of a futures contract negatively (Carlton, 1984). Bekkerman and Tejeda (2017) states that vertical integration results in less pricing points and thus less competitive price determination, and that it leads to a lower need for hedging because hedging occurs within a firm structure.

6. Buyer Concentration

Bekkerman and Tejeda (2017) argues that high buyer concentration in an industry can lead to reduced cash market activeness and make it possible for firms to manipulate prices. High buyer concentration is thus expected to have a negative effect on the success of a futures contract.

7. Risk Reduction Through Futures Cross-Hedging

For an own-hedge futures contract to be successful, it must provide a better hedge than an existing, alternative cross-hedge contract (Black, 1986). The higher is the remaining price risk after cross-hedging, the higher should be the desirability of an own-hedge contract (Bekkerman & Tejeda, 2017). If the uncertainty in one commodity is correlated with the uncertainty in another, it is less likely to see two separate futures contracts for these commodities (Carlton, 1984).

8. Liquidity of the Cross-Hedge Futures Contract

If a cross-hedge futures contract is very liquid, it might make an own-hedge contract less applicable for the market participants (Black, 1986). The cost of using an own-hedge futures contract might outweigh the potential higher hedging efficiency offered by it. On the other hand, if the cross-hedge futures contract is less liquid, it should increase the probability of an own-hedge contract achieving success.

Brorsen and Fofana (2001) finds that higher liquidity of a cross-hedge contract has a negative effect on both volume and open interest of an own-hedge contract.

9. Storability

Bekkerman and Tejeda (2017), Bergfjord (2007), and Black (1986) mention storability as a factor contributing to success. Storability allows for easy and flexible delivery, buying and selling, which facilitate the exploitation of potential arbitrage opportunities that secures a close relationship between spot and futures prices (Bergfjord, 2007).

10. Free Flow of Information and Goods

Bergfjord (2007) argues that free flow of information and goods may also be important success factors. Without public price data, the futuress price may not reflect the true spot prices, and speculators will be less willing to take part in the futures market. Free flow of goods entails that the degree of government intervention should be low, and transportation costs should not be large. The opposite will make fulfillment of a futures contract, even in the case of cash settlement, more difficult.

3.2 Factors Related to the Exchange and Its Users

Several papers find that characteristics of potential users of a futures contract are important for the success of a futures contract. The presence of risk aversion among potential market participants have been found to be an important factor for the success of a contract (Tashjian & Weissman, 1995). Gray (1966) finds that firms must want to use the contract for hedging, and that speculators must be attracted to the market to provide liquidity. Tashjian (1995) also mentions that differences between long and short market participants, for instance in risk aversion, can lead one side to give price concessions to the other, which in turn will attract speculators, i.e. liquidity, and larger trading volume from one of the parties.

Sanders and Manfredo (2002) suggests that collaboration between potential users of a futures contract and the exchange planning to offer it, as well as user commitment, is important. The paper also highlights that the exchange must educate potential traders and not take for granted that they are already familiar with the practices and benefits of using futures contracts.

3.3 Factors Related to Contract Design

Although factors regarding the underlying commodity market, other futures markets, and the exchange and its users may speak in favour of a potential futures contract, the design of the contract is still important. Bergfjord (2007) and Black (1986) point to three main aspects related to contract design and futures market success:

1. Attractiveness to hedgers
2. Attractiveness to speculators
3. Flexibility versus vulnerability to manipulation

These three aspects state that the contract must be designed in such a way that both hedgers and speculators are attracted, and that the contract must balance the trade-off between flexibility and vulnerability to manipulation.

Attracting both hedgers and speculators is important to the success of a futures contract (Bergfjord, 2007; Black, 1986; Gray, 1966; Tashjian & Weissman, 1995). Attractiveness to both will lead to a higher volume of trade (Bergfjord, 2007).

Bergfjord (2007) argues that matching the needs of speculators is more of a formality, while several contract provisions will affect the attractiveness to hedgers. In attracting hedging, Powers (1967) states that close correspondence between contract provisions and trade practices is important. Conformity with commercial movements is also stressed by Gray (1966). Main aspects that affect the attractiveness to hedgers include the degree of hedging effectiveness, settlement form (cash or physical delivery), and construction of the settlement price index (Bergfjord, 2007). Contract provisions such as contract size and maturity months can also be of importance (Aldinger, 1991).

The higher flexibility a futures contract offers, the more sellers would find it appealing, but it might open for manipulation (Bergfjord, 2007). If there is one large player controlling the cash price of the commodity, this player may manipulate cash prices to gain in the futures market (Carlton, 1984).

4. Data, Theory and Methodology

In this chapter, an overview of the methodological approach used in this thesis, as well as the data, theory and specific methodology applied in quantitative analysis, will be presented.

Subchapter 4.1 will present a brief overview of the methodological approach used in this thesis, Subchapter 4.2 will present the data utilised, and Subchapter 4.3 will present the econometric theory applied. Finally, Subchapter 4.4 will present the model of Bekkerman and Tejeda (2017), which will be applied to predict the probability of fishmeal futures contract existence. Included in this chapter is also a presentation of the Delphi method, which is applied to obtain some of the measures for fishmeal used in Bekkerman and Tejeda's (2017) model.

4.1 Methodological Approach

In the following, the methodological approach of this thesis, which consists of both quantitative and qualitative analyses, will be presented.

The quantitative analysis is carried out through two separate approaches. First, we want to develop an understanding of the fishmeal cash market by testing for cointegration between different fishmeal cash price series of different origins and qualities. The existence of cointegration can indicate that fishmeal has an effective and acknowledged grading system and whether the global fishmeal market is integrated, and thus the size of the market. The motivation for the cointegration tests is that both the effectiveness of grading, i.e. product homogeneity, and the cash market size have been mentioned by the literature as important success factors. To test for cointegration, tests for non-stationarity must also be conducted.

Second, we apply the model developed by Bekkerman and Tejeda (2017) to predict the probability of existence of a fishmeal futures contract. This model is, in large, based on a similar model developed by Brorsen and Fofana (2001) and partly on research conducted by Black (1986). The eight first success factors presented in Subchapter 3.1 will be analysed in this model. Following Bekkerman and Tejeda (2017) and Brorsen and Fofana (2001), a survey will be conducted through use of the Delphi method. In this survey, we collect quantitative measures that will be used in Bekkerman and Tejeda's (2017) model.

The quantitative analysis is followed by a qualitative analysis and discussion of the factors and aspects related to the success of futures contracts presented in Chapter 3.

4.2 Data

The data utilised in this thesis include fishmeal cash prices, soybean meal and corn futures prices and trading volume, and fishmeal market and trade statistics. In addition, a survey on fishmeal characteristics and the fishmeal market has been carried out. To the extent that the data have been subject to econometric analysis, Stata 15 has been used.

4.2.1 Fishmeal Cash Prices

Several fishmeal price series of different qualities (protein content) and country of origin will be subject to analysis in this thesis. All cash price series of fishmeal have been provided by courtesy of IFFO – The Marine Ingredients Organisation.

The fishmeal prices are of Peruvian (64%, 67% and 68% protein content), Chilean (68% protein content), Icelandic (71% protein content), and Danish (72% protein content) origin. All price series have been collected on a weekly basis, and the day of collection has been set to Wednesdays or the closest business day. Prices have been collected for the time periods of 04.01.2005-23.01.2018, 13.07.2010-23.01.2018 and 05.01.2010-23.01.2018 for Peruvian fishmeals, Chilean fishmeal, and Icelandic and Danish fishmeal, respectively. Weekly collection gives the largest number of observations, i.e. sample size, in our dataset, and has also been necessary to apply the model of Bekkerman and Tejeda (2017) on fishmeal. There are no missing data points in the collected price series, nor are there extreme outliers. We are of the opinion that weekly data collection gives the best representation of the characteristics that this thesis seeks to investigate, for instance in terms of cash market activeness.

There is some variation with regards to Incoterms[6] between some of the price series. In the price series, fishmeals of Peruvian and Chilean origin are subject to FOB (Free on Board) Incoterms, while fishmeals of Icelandic and Danish origin are subject to CFR (Cost and Freight) Incoterms. The mentioned Incoterms have different allocations of commercial related

[6] Incoterms are a series of standardised commercial terms widely used in global trade that regulate how risks and costs are divided between buyers and sellers of goods (International Chamber of Commerce, 2018).

costs to buyers and sellers, and all else equal, goods subject to CFR will have a higher price than goods subject to FOB. The reader should have in mind that the differences in Incoterms potentially can weaken the comparison and relationships across price series due to potential variation and divergence in commercial related costs. For a more detailed overview of the differences between FOB and CFR, the reader may consult Table A1 in Appendix A.

A detailed overview of all relevant fishmeal price series, with a description of units, Incoterms, country of origin, minimum protein content and time period follows in Table 2. The price series are plotted in Figure 10 in Section 2.2.3. For descriptive statistics of the price series, the reader may consult Table A2 in Appendix A.

Table 2: Overview of Relevant Fishmeal Cash Price Series

Cash price series	Unit	Incoterm	Country of origin	Minimum protein content	Time period
Fishmeal Peru 64%	USD/MT	FOB	Peru	64 %	04.01.2005-23.01.2018
Fishmeal Peru 67%	USD/MT	FOB	Peru	67 %	04.01.2005-23.01.2018
Fishmeal Peru 68%	USD/MT	FOB	Peru	68 %	04.01.2005-23.01.2018
Fishmeal Chile 68%	USD/MT	FOB	Chile	68 %	13.07.2010-23.01.2018
Fishmeal Iceland 71%	USD/MT	CFR	Iceland	71 %	05.01.2010-23.01.2018
Fishmeal Denmark 72%	USD/MT	CFR	Denmark	72 %	05.01.2010-23.01.2018

When analyses are restricted to only one price series in this thesis, Fishmeal Peru 68% has been chosen. This is because its high protein content is comparable to Nordic origin fishmeal. Additionally, it is natural to choose a Peruvian origin fishmeal, due to the country's status as the largest fishmeal producer in the world.

4.2.2 Soybean Meal and Corn Futures Prices and Trading Volume

Weekly prices and trading volumes for soybean meal and corn futures contracts listed on the Chicago Board of Trade (CBOT) for the time period 04.01.2005-23.01.2018 have been retrieved from a Bloomberg Terminal. The contracts are the so-called "1st generic" contracts, i.e. the contract closest to maturity at a given date, and the day of collection has been set to coincide with the day of collection of the fishmeal prices. The price collected is the last price.

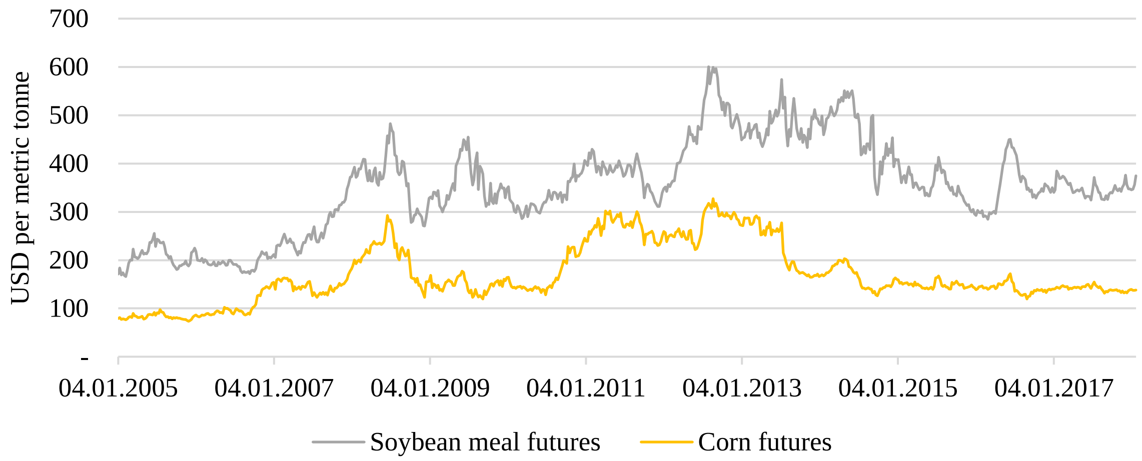
Soybean meal futures contracts are quoted in US dollars per short ton, and each contract is for 100 short tons (CME Group, 2018a). Corn futures contracts are quoted in US cents per bushel, and each contract is for 5 000 bushels (CME Group, 2018b).

To ensure comparability to the fishmeal prices, all weekly futures prices have been converted to US dollars per metric tonne. An overview of the relevant soybean meal and corn futures contracts, with descriptions of unit, price type, contract and exchange follows in Table 3. Additionally, the futures price series are plotted in Figure 12. For descriptive statistics of the price series, the reader may consult Table A2 in Appendix A.

Table 3: Overview of the Soybean Meal and Corn Futures Contracts

Futures price series	Unit	Price Type	Contract	Exchange
Soybean Meal	USD/MT	Last price (close)	1st generic	CBOT
Corn	USD/MT	Last price (close)	1st generic	CBOT

Figure 12: Soybean Meal and Corn Futures Prices



Source: Bloomberg Terminal

4.2.3 Fishmeal Market and Trade Statistics

Fishmeal market and trade statistics will be subject to analysis in this thesis. Statistics on yearly production, imports, exports and domestic consumption of fishmeal both aggregated and sorted on all world countries for the time period 2005-2017 have been collected from United States Department of Agriculture's Production, Supply & Distribution Database (PSD). All market and trade statistics collected are measured in metric tonnes.

4.2.4 Survey on Fishmeal

Data collected from a selected pool of respondents in a survey on fishmeal will be applied to Bekkerman and Tejeda's (2017) model in this thesis. The method of the survey is explained in detail in Section 4.4.2. An overview of the respondents can be found in Table A3 in Appendix A, and an overview of the questions in the survey can be found in Section A1 in Appendix A.

4.3 Econometric Theory

In this subchapter, econometric theory and tests applied in this thesis will be presented. Hill, Griffiths and Lim (2012) has been used as reference and will not be referenced in-text unless it is especially called for. Additional sources of theory are referenced when relevant.

4.3.1 Stationary and Non-Stationary Time Series

In the following, theory regarding stationary and non-stationary time series will be presented. A thorough understanding of these concepts are important to understand cointegration, which is a concept used in the quantitative analysis in this thesis. This section will first provide an explanation of stationary time series, and then an explanation of non-stationary time series. Equations are adapted from Hill et al. (2012).

Stationary Time Series

A time series variable Y_t is defined to be stationary if its mean and variance are constant and finite for all times, and the covariance between two values from the time series only is dependent on the length of time between them and not on the time of observance of the variables. The mean, variance and covariance are in other words independent of time. The constant, finite mean condition is also known as mean reversion.

Formally, a time series variable Y_t is stationary if the following conditions hold for all values and for all time periods (Hill et al., 2012; Verbeek, 2012):

$$E(Y_t) = \mu < \infty \ (constant, finite\ mean) \tag{4.1}$$

$$Var(Y_t) = \sigma^2 < \infty \ (constant, finite\ variance) \tag{4.2}$$

$$Cov(Y_t, Y_{t+s}) = Cov(Y_t, Y_{t-s}) = \gamma_s \; (covariance\ depends\ on\ s, not\ t) \qquad (4.3)$$

Non-Stationary Time Series

In the following, the first-order autoregressive, or AR(1), model is used to explain the difference between stationary and non-stationary time series. Variations of the random walk model are presented to explain non-stationary time series.

The First-Order Autoregressive Model

An AR(1) model is given by:

$$Y_t = \rho Y_{t-1} + v_t, \qquad |\rho| < 1 \qquad (4.4)$$

The error term v_t is independent, has a zero-mean and constant variance σ_v^2. Additionally, the error term may be normally distributed. The assumption that $|\rho| < 1$ implies that Y_t is a stationary time series.

Hill et al. (2012) shows with recursive substitution that the mean of Y_t equals zero, i.e. is constant:

$$E_0(Y_t) = (v_t + \rho v_{t-1} + \rho^2 v_{t-2} + \cdots) = 0 \qquad (4.5)$$

This is because the error term v_t has a zero-mean, and the value of $\rho^t Y_0$ is of negligible size when t is large. Hill et al. (2012) further states, implicitly assuming a large t at time zero, that the variance of Y_t can be shown to equal a constant $\frac{\sigma_v^2}{(1-\rho^2)}$, and that the covariance between two error terms s periods apart from each other γ_s can be shown to equal $\frac{\rho^s \sigma_v^2}{(1-\rho^2)}$. The conditions of stationarity in Equations 4.1, 4.2 and 4.3 therefore hold for an AR(1) model. Hill et al. (2012) also shows that this holds true for an adjustment of the AR(1) model with a non-zero mean and $|\rho| < 1$.

Random Walk Models

Random Walk

The random walk model is a special case of an AR(1) model where $|\rho| = 1$. The model is given by:

$$Y_t = Y_{t-1} + v_t \qquad (4.6)$$

Each realisation of Y_t contains the value of last period's value Y_{t-1} and an error term v_t. The name "random walk" comes from the appearance of a patternless, slow upward and downward wandering[7] of the time series. In the time series, values of sample means calculated from subsamples will be dependent on the sample period, which is a characteristic of non-stationary series. The behaviour of a random walk can be understood by applying recursive substitution:

$$Y_1 = Y_0 + v_1 \tag{4.7}$$

$$Y_2 = Y_1 + v_2 = (Y_0 + v_1) + v_2 = Y_0 + \sum_{s=1}^{2} v_s \tag{4.8}$$

$$Y_t = Y_{t-1} + v_t = Y_0 + \sum_{s=1}^{t} v_s \tag{4.9}$$

The random walk model consists of an initial value-term Y_0 and a sum of previous stochastic terms $\sum_{s=1}^{t} v_s$. The stochastic component v_t is added for each time t, which leads the series to trend in unpredictable directions.

One can use the fact that Y_t is given by a sum of error terms (Y_0 is often set to zero because of its negligible contribution to Y_t when t is large) to explain why the random walk model is non-stationary. Because the error terms v_t are independent, the expectation and variance, at time zero, of Y_t are:

$$E_0(Y_t) = Y_0 + E_0(v_1 + v_2 + \cdots + v_t) = Y_0 \tag{4.10}$$

$$Var_0(Y_t) = Var_0(v_1 + v_2 + \cdots + v_t) = t\sigma_v^2 \tag{4.11}$$

As evident in Equations 4.10 and 4.11, the random walk model has a mean equaling its initial value[8] and a time-increasing variance, which will eventually become infinite when $t \to \infty$. A time-dependent, eventually becoming infinite, variance violates Equation 4.2. Thus, the random walk model is non-stationary.

[7] Not to be confused with deterministic drift.

[8] «Inital value» refers to the value of Y_c when taking the expectation E_c.

Random Walk with Drift

The random walk with drift model is obtained by adding a constant term to the random walk model, and is given by:

$$Y_t = \alpha + Y_{t-1} + v_t \tag{4.12}$$

The random variable Y_t contains an intercept α (drift component), the last period's variable Y_{t-1} and the error term v_t. Generally, the model expresses a definite trend upward when $\alpha > 0$, and downward when $\alpha < 0$.

The behaviour of a random walk with drift can be understood by applying recursive substitution:

$$Y_1 = \alpha + Y_0 + v_1 \tag{4.13}$$

$$Y_2 = \alpha + Y_1 + v_2 = \alpha + (\alpha + Y_0 + v_1) + v_2 = 2\alpha + Y_0 + \sum_{s=1}^{2} v_s \tag{4.14}$$

$$Y_t = \alpha + Y_{t-1} + v_t = t\alpha + Y_0 + \sum_{s=1}^{t} v_s \tag{4.15}$$

Y_t consists of an initial value-term Y_0, a stochastic trend component $\sum_{s=1}^{t} v_s$ and a deterministic trend component $t\alpha$. The term deterministic trend comes from the fact that a fixed value α is added for each time t. The behaviour of a random walk with drift is thus different from a random walk model, because Y_t wanders upward and downward randomly in addition to trend in a certain direction with a fixed amount over time. Y_t has a mean and variance of:

$$E_0(Y_t) = t\alpha + Y_0 + E_0(v_1 + v_2 + \cdots + v_t) = t\alpha + Y_0 \tag{4.16}$$

$$Var_0(Y_t) = Var_0(v_1 + v_2 + \cdots + v_t) = t\sigma_v^2 \tag{4.17}$$

The mean is either increasing or decreasing with time, depending on the sign of α, thus violating the constant, finite mean condition of stationary series in Equation 4.1. Additionally, the variance of the random walk with drift model is the same as that of the random walk model, which also breaks with the constant variance condition of stationary series in Equation 4.2. Thus, the random walk with drift model is non-stationary.

Spurious Regression

Spurious regression, a term initially coined and explained by Granger and Newbold (1974), describes the phenomenon of invalid and inflated coefficients of determination (R^2) and test statistics when regressing non-stationary time series on each other. In layman's terms, regressing non-stationary time series on each other can indicate that there are strong relationships between time series, and that the model obtained from the regression is well specified, even if none of this is true. Parts of this thesis seeks to draw conclusions and look for indications of relationships between time series variables. Many financial time series, such as commodity prices, inhibits a trending pattern due to gradual evolvement in for instance technology, biology, climate conditions, consumer preferences and demographics. Time series inhibiting such a trend break with the conditions of stationarity, and thus many financial time series are non-stationary. To be able to interpret our results as non-spurious, true effects, testing for non-stationarity is crucial. The presence of non-stationarity is also a prerequisite for the existence of a cointegration relationship, which is tested for in this thesis.

Testing for Stationarity and Non-Stationarity

In this thesis, the presence of both stationarity and non-stationarity is tested by utilising unit root tests. Unit root tests utilise the fact that the absolute value of the coefficient ρ differs for stationary and non-stationary time series, as explained earlier in this subchapter. A unit root, or non-stationarity, is present if the coefficient ρ has an absolute value of 1. In this thesis, both the Augmented Dickey-Fuller (ADF) test, Dickey-Fuller Generalised Least-Squares (DF-GLS) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test have been used, and the test procedures will be presented in the following.

Augmented Dickey-Fuller

The standard Dickey-Fuller test procedure was developed by Dickey and Fuller (1979). The null hypothesis is that the variable is containing a unit root, i.e. is non-stationary, and the alternative hypothesis is that the variable is not containing a unit root, i.e. is stationary.

The Dickey-Fuller test regresses the following model via ordinary least squares (StataCorp LLC, 2018a):

$$Y_t = \alpha + \rho Y_{t-1} + \delta t + u_t \tag{4.18}$$

Setting $\alpha = 0$ or $\delta = 0$ if supressing drift (constant) or a time trend, respectively, is of interest. After the desired model is specified, the null hypothesis of $|\rho| = 1$ is tested.

Time series tested in the standard Dickey-Fuller are in many cases subject to serial correlation. Therefore, the Augmented Dickey-Fuller test includes lags of Y_t to control for serial correlation. The regression model is refitted to the following form:

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \delta t + \sum_{i=1}^{K} \theta_i * \Delta Y_{t-i} + \epsilon_t \tag{4.19}$$

K is the number of lags of Y_t included to correct for serial correlation. In the ADF test, the null hypothesis is that $\beta = 0$, which is analogous to testing $|\rho| = 1$ in the standard Dickey-Fuller test.

Upon visual inspection of the time series studied in this thesis, all seem to follow an upward trend and have a non-zero mean. Based on this inspection, two separate ADF tests have been conducted: one containing a *constant* (restriction of $\delta = 0$) and one containing a *constant and trend* (no restrictions).

Dickey-Fuller Generalised Least-Squares

The Dickey-Fuller Generalised Least-Squares (DF-GLS) test was proposed by Elliot, Rothenberg and Stock (1996). The test follows the exact same approach as the ADF test, except that the time series variables are transformed through a generalised least squares (GLS) regression prior to the test (StataCorp LLC, 2018b). The null hypothesis is thus that Y_t is containing a unit root, i.e. is non-stationary, while the alternative hypothesis is that Y_t is not containing a unit root, i.e. is stationary. The test allows for controlling for both trends and constants, as for the ADF test, and thus tests with *constant* (restriction of $\delta = 0$) and *constant and trend* (no restrictions), have been conducted on all price series.

Kwiatkowski-Phillips-Schmidt-Shin

The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test was proposed by Kwiatkowski, Phillips, Schmidt and Shin (1992). The exact derivation of the KPSS test can be observed in their paper *Testing the null hypothesis of stationarity against the alternative of a unit root* (1992). As the name of the paper reveals, the KPSS test differs from the standard unit root tests by testing a null hypothesis of Y_t not containing a unit root, i.e. that the series is stationary, while the alternative hypothesis is that Y_t contains a unit root, i.e. that the series is non-stationary. This test has been conducted to verify and supplement the test results from the ADF and DF-GLS tests, and as for them, the KPSS test allows for tests with *constant* and *constant and trend*, which have been conducted on all price series.

4.3.2 Cointegration

In the following, theory regarding cointegration will be presented. Tests for cointegration are used in the quantitative analysis in this thesis, as an indication of the degree to which fishmeal is a homogeneous commodity and whether fishmeal has one or more markets.

Generally, regressing non-stationary time series variables produces spurious results. There is, however, an exception to that; if Y_t and X_t are two non-stationary variables integrated of order 1, also known as $I(1)$, i.e. are non-stationary in level and stationary in first-difference form, then linear combinations of these two variables are expected to be $I(1)$ too. If there exists a linear combination of Y_t and X_t that is $I(0)$, i.e. stationary in levels, then Y_t and X_t are said to be cointegrated. Cointegrated variables inhibit a long-term equilibrium relationship, and in the long-run the difference between the variables will be stationary. This implies that regressing cointegrated variables will not produce spurious results, and this is the only exception to the rule of not regressing non-stationary variables on each other.

Testing for Cointegration

In this thesis, the presence of cointegration is tested by applying the Engle-Granger test. This test will be presented in the following. The Johansen Procedure, with the Trace test and Maximum Eigenvalue test, as presented in Johansen (1988), Johansen (1991) and Johansen and Juselius (1990), has also been considered. The Engle-Granger test has, however, been deemed to be sufficient for the purpose of detecting bivariate cointegration relationships between price series in this thesis.

Engle-Granger

The Engle-Granger test was proposed by Engle and Granger (1987). The test follows two steps (Schaffer, 2018):

1. Y_t is regressed on a constant and X_t, and the residuals u_t from the regression are estimated
2. First-differenced u_t is regressed on the lagged level u_t without a constant

After following these steps, the Engle-Granger test statistic is the equivalent to the standard OLS t-statistic on the lagged level u_t. The null hypothesis of the Engle-Granger test is that the residual is non-stationary, i.e. that there does not exist a cointegrating vector for Y_t and X_t, and the alternative hypothesis is that the residual is stationary, i.e. that there exist a cointegrating vector for Y_t and X_t. An augmented version of the Engle-Granger test allows for lags of the first-differenced u_t to be included in case the error terms are not serially independent, and this augmented version is applied when appropriate. In addition, an Engle-Granger test that includes a linear time trend is also applied. Both *constant* (not including a time trend) and *constant and trend* tests will be conducted in this thesis.

4.3.3 Assumptions and Diagnostic Tests

In the following, a very brief overview of assumptions and diagnostic tests relevant for time series regression is presented. We assume that the assumptions are known to the reader, and they are therefore not presented in detail[9]. The diagnostic tests are mentioned by name, but not presented[10].

For time series regression to give the best linear unbiased estimator and for inference to be the same as that of traditional OLS, both Gauss Markow assumptions and the additional assumption that the error term u_t is independent from any independent variables and independently and identically distributed (i.i.d.) as $N(0, \sigma^2)$, must hold (Woolridge, 2016).

Where applicable, diagnostic tests have been applied to validate these mentioned assumptions. More specifically, the presence of heteroskedasticity have been tested with three versions of the Breusch-Pagan and Cook-Weisberg tests (StataCorp LLC, 2018c), the presence of ARCH effects (conditional heteroskedasticity) have been tested with Engle's Lagrange multiplier test (StataCorp LLC, 2018d), the presence of serial-/autocorrelation have been tested with the Breusch-Godfrey test for higher-order serial-correlation (StataCorp LLC, 2018d), Durbin's alternative test for serial-correlation and the Durbin-Watson test for first-order serial-correlation (StataCorp LLC, 2018d), and the presence of normality have been tested with the Shapiro-Wilk normality test (StataCorp LLC, 2018e). The results of these tests are not reported in this thesis, but do not indicate that any econometric results that are presented and utilised are invalid or materially affected by breaches of the mentioned assumptions.

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[9] If not, we refer to Chapter 10 and 11 in Woolridge (2016), which gives an explanation of them.

[10] For an explanation of the tests, the reader can consult StataCorp, which is referenced in-text.

4.4 The Bekkerman & Tejeda Model

Several studies have aimed at empirically investigating which factors contribute to the success of futures contracts on agricultural commodities. Black (1986) presents a model that includes several of the factors that today are considered of highest importance, but its focus is on non-agricultural commodities. The model is extended by Brorsen and Fofana (2001), which focuses on agricultural commodities. Brorsen and Fofana's (2001) model is further developed by Bekkerman and Tejeda (2017). While the two latter models have many similarities, only Bekkerman and Tejeda's (2017) investigates the relative importance of different factors.

While Brorsen and Fofana (2001) applies a two-step method to estimate both contract volume and open interest, Bekkerman and Tejeda (2017) estimates a two-stage mixture model including an "entry" stage that estimates the probability of a commodity having a futures contract, and an "activity" stage that estimates only the trading volume[11]. While the first stage includes commodities both with and without futures contracts, the second stage exclusively includes commodities with futures contracts.

Bekkerman and Tejeda's (2017) model is extended compared to the model of Brorsen and Fofana (2001), as the former also includes market participant characteristics in a separate version of the second stage. However, only the first stage is of relevance to the quantitative analysis in this thesis, as no futures contract exists for fishmeal today. This "entry" stage of Bekkerman and Tejeda's (2017) model is applied to investigate the viability of a fishmeal futures contract in an out-of-sample prediction. By collecting and compiling measures of the different factors that are included in the model, a probability of fishmeal futures contract existence can be predicted.

However, while Bekkerman and Tejeda's (2017) model, based on current characteristics, is applied to better determine whether a fishmeal contract is viable, it is important to note what it actually measures – the probability of a commodity having a futures contract. Because Bekkerman and Tejeda's (2017) model reflects commodities both with and without futures contracts, the estimated coefficients might not reflect the true probability of a new futures

[11] Bekkerman and Tejeda (2017) agrees on Black's (1986) and Brorsen and Fofana's (2001) definitions of success, but argues that volume and open interest are highly correlated. Hence, contract open interest is not estimated.

contract achieving success. Rather, it might better reflect whether fishmeal appears to be having a futures contract *today*[12]. This potential "flaw" of the model will be subject to discussion in the qualitative assessment in Subchapter 6.1.

Similar to Brorsen and Fofana (2001), Bekkerman and Tejeda (2017) uses measures of uncertainty, cash market size, product homogeneity (or grading effectiveness), cash market activeness, degree of vertical integration, degree of buyer concentration, risk reduction through futures cross-hedging, and liquidity cost of the cross-hedge futures contract as explanatory variables in the model.

4.4.1 Measures of Success Factors

Bekkerman and Tejeda (2017) estimates the following first stage model[13]:

$$\begin{aligned} &Probability\ of\ a\ commodity\ having\ a\ futures\ market\ in\ year\ t \\ &\quad = -5.79 - 0.07CV_{i,t} + 1.07\ln(Y_{i,t}) + 0.11(26 - ACM_{i,t}) \\ &\quad + 0.86Hom_i - 2.27VI_i - 5.98Con_i - 0.43ln(XVol_{j,t}) \\ &\quad - 2.82RR_{i,t} \end{aligned} \tag{4.20}$$

The measurement procedures for the variables will be presented in the following. Equations and procedure steps are adapted from Bekkerman and Tejeda (2017).

Uncertainty

The uncertainty criteria will be measured through cash price variability, by calculating the coefficient of variation (CV). This is found by dividing the standard deviation of weekly cash prices $P_{i,t,s}$ by the mean of weekly cash prices, for each year (52 weeks)[14]:

[12] It should be noted that Bekkerman and Tejeda (2017) re-estimated their model using only commodities with more active futures markets (defined as futures markets with trade volumes of, on average, 10 000 contracts or greater), for robustness of the results, and that the same qualitative conclusions were reached and only marginal quantitative differences from the estimated parameters on the entire data sample were found.

[13] Subscript i refers to the commodity being analysed, i.e. fishmeal. Subscript j refers to the commodity that commodity i's assumed cross-hedge futures contract is written on. Subscript s, used in several equations following in this section, refers to week number.

[14] Following Bekkerman and Tejeda (2017), CV measures are scaled to integer form (that is, multiplied by a factor of 100).

$$CV_{i,t} = \frac{STD\ (P_{i,t,s=1}, P_{i,t,s=2}, \ldots P_{i,t,s=52})}{E(P_{i,t,s=1}, P_{i,t,s=2}, \ldots P_{i,t,s=52})} \quad (4.21)$$

Size of the Cash Market

The size of the cash market (Size) is measured as the annual production $Y_{i,t}$, in tonnes[15]. Brorsen and Fofana's (2001) model uses annual US production, and Bekkerman and Tejeda (2017) is assumed to have done the same. Due to the geographically fragmented production of fishmeal, this thesis applies annual world production of fishmeal. The natural logarithm is applied in the model:

$$Size = ln(Y_{i,t}) \quad (4.22)$$

Activeness of the Cash Market

The activeness of the cash market (ACM) will be measured through two different procedures. The first procedure assumes that the activeness of the cash market is time-invariant and is estimated using the Delphi method, a survey method explained in detail in Section 4.4.2. This method is also applied in the estimation of homogeneity, vertical integration and buyer concentration, as described later in this subchapter. The second procedure allows for different levels of cash market activeness in different years and is found empirically following the approach of Bekkerman and Tejeda (2017). The latter is also the procedure that will be applied in the model:

$$ACM_{i,t} = E(NC_{i,t,s=1}, \ldots, NC_{i,t,s=52}) \quad (4.23)$$

$ACM_{i,t}$ is found through the following procedure:

1. Calculate first-differenced weekly prices, $\Delta P_{i,s} = P_{i,s} - P_{i,s-1}$
2. For each week s, determine the number of times in the preceding 26 weeks that $\Delta P_{i,s} = 0; that\ is, NC_{i,t,s}$.
3. For each year t, estimate the expected value of the number of weeks within each 26 week rolling lag; that is, $ACM_{i,t} = E(NC_{i,t,s=1}, \ldots NC_{i,t,s=52})$.

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[15] $Y_{i,t}$ must not to be confused with Y_t used in the explanation of (non-)stationarity and cointegration in Subchapter 4.3.

Data from before 04.01.2005 is not part of our sample, and hence the ACM measures for the 26 first weeks of 2005 cannot be estimated. For 2005, the yearly ACM measure will represent the average ACM measure estimated for the last 26 weeks of that year. It should also be noted that the measure used when predicting the probability of existence of a fishmeal futures contract is 26 minus the ACM measure; that is, the expected value of the number of weeks that $\Delta P_{i,s} \neq 0$.

Product Homogeneity

The degree of product homogeneity (Hom) is assumed to be time-invariant and is measured through the Delphi method. While Bekkerman and Tejeda (2017) applies homogeneity measures found by Brorsen and Fofana (2001), we estimate our own measure for fishmeal using the same procedure:

$$Product\ homogeneity = Hom_i$$
$$Hom_i = 0, if\ Hom_{i,Delphi} < 5;\ Hom_i = 1\ otherwise \tag{4.24}$$

Degree of Vertical Integration

The degree of vertical integration (VI) is assumed to be time-invariant and is measured through the Delphi method. While Bekkerman and Tejeda (2017) applies measures of vertical integration found by Brorsen and Fofana (2001), we estimate our own measure for fishmeal using the same procedure:

$$Vertical\ integration = VI_i$$
$$VI_i = 0, if\ VI_{i,Delphi} < 5;\ V_i = 1\ \ otherwise \tag{4.25}$$

Degree of Buyer Concentration

The degree of buyer concentration (Con) is assumed to be time-invariant and is measured through the Delphi method. While Bekkerman and Tejeda (2017) applies measures of buyer concentration found by Brorsen and Fofana (2001), we estimate our own measure for fishmeal using the same procedure:

$$Buyer\ concentration = Con_i \tag{4.26}$$

$$Con_i = 0, if\ Con_{i,Delphi} < 5;\ Con_i = 1\ otherwise$$

Liquidity Cost of the Cross-Hedge Futures Contract

The liquidity cost of the cross-hedge futures contract (XVol) is measured as the natural logarithm of the average weekly contract volume of the cross-hedge futures contract traded each year:

$$ln(XVol_{j,t}) = ln(\frac{1}{52}\sum_{s=1}^{52} Vol_{j,t,s}) \quad (4.27)$$

Risk Reduction through Futures Cross-Hedging

Risk reduction through futures cross-hedging is measured as the residual risk, i.e. the price risk remaining after cross-hedging.

$$Residual\,risk = RR_{i,t} \quad (4.28)$$

$RR_{i,t}$ is found by regressing the cash price $P_{i,t}$ of fishmeal on the futures price $F_{j,t}$ of a cross-hedge commodity, and then retrieving the coefficient of determination (R^2) through the following procedure:

1. Estimate $P_{i,t} = \beta_0 + \beta_1 F_{j,t} + \varepsilon_{i,t}$
2. Retrieve coefficient of determination, $\tilde{R}^2$
3. $RR_{i,t} = (1 - \tilde{R}^2)$

Past literature, such as Asche and Tveterås (2004), Franken and Parcell (2011), Gjerde (1989), and Vukina and Anderson (1993), suggest that both soybean meal and corn futures contracts may be suitable candidates for cross-hedging fishmeal.

In estimating the residual risk measure, Bekkerman and Tejeda (2017) follows assumptions made in Brinker, Parcell, Dhuyvetter and Franken (2009), Graff, Schroeder, Jones and Dhuyvetter (1997), and Zacharias, Lange, Gleason and Traylor (1987). Brinker et al.'s (2009) empirical model follows Sanders and Manfredo (2004), with the notable exception that cash and futures prices are not first-differenced. This model corresponds to the method used in Bekkerman and Tejeda (2017), as presented in this section. Following this model, with level cash and futures prices, will yield spurious regression results (notably an inflated coefficient of determination), if the time series variables are neither $I(0)$ nor $I(1)$ and cointegrated.

Therefore, all yearly price series of Fishmeal Peru 68%, soybean meal futures and corn futures are tested for stationarity in both levels and first-difference, and the two latter are tested for bivariate cointegration with Fishmeal Peru 68%. ADF tests with both *constant* and *constant and trend* are applied to test for stationarity. Where the ADF tests generate ambiguous results, KPSS tests and/or DF-GLS tests are applied. Engle-Granger tests with both *constant* and *constant and trend* are applied to test for cointegration. Test results are reported in Table A4 and Table A5 in Appendix A. The tests indicate that all the time series variables are $I(1)$ and not cointegrated, with some exceptions[16]. Therefore, the original first-differenced model presented in Sanders and Manfredo (2004) is followed to retrieve a consistent coefficient of determination. Cochrane Orcutt estimation, a method first described in Cochrane and Orcutt (1949), is utilised in the case of autocorrelation. In this thesis, only cross-hedge strategies with one futures contract are explored. The results from the cross-hedge futures contract that yields the highest average yearly coefficient of determination across the relevant time period are included in the model.

4.4.2 The Delphi Method

Some of the factors important for futures contract success are difficult to quantitatively measure. A technique that to some extent overcomes this problem is the Delphi method.

The Delphi method utilises experts' opinions in a group setting to find estimates of figures that cannot be directly measured (Helmer, 1967). The method has been used in former research on topics related to agricultural commodities (e.g. Brorsen & Fofana, 2001). The process is as follows (Helmer, 1967): First, relevant experts assumed to have extensive industry knowledge are selected. Second, the selected experts are given a set of questions or statements to which they subscribe, on a scale of 1-10, that the commodity possesses certain characteristics. Third, the responses are summarised, and the median and the interquartile range, or alternatively the average and standard deviation following Brorsen and Fofana (2001), are calculated for each variable. Fourth, these figures are returned to each of the respondents. The respondents whose answers fall out of the interquartile range or one standard deviation from the mean are given the opportunity to adjust their responses. If these respondents still choose a number outside

[16] See Table A4 and Table A5 in Appendix A, where exceptions are highlighted in notes.

the range, they are asked to explain why. Finally, the median or average of all second-round responses is used as an estimate of group consensus.

The process can then be repeated for one or more rounds, where respondents can also be given other respondents' answers, anonymously.

While Helmer (1967) uses interquartile range and median in its use of the method, Brorsen and Fofana (2001) uses averages and standard deviations when investigating the characteristics of several agricultural commodities. Because Bekkerman and Tejeda (2017) adapts Brorsen and Fofana's (2001) findings from the Delphi survey to its model, respondents are also given averages and standard deviations in our survey.

Characteristics for Examination

The characteristics of the fishmeal market that the respondents are asked to grade are homogeneity, activeness of the cash market, vertical integration and buyer concentration[17].

Respondents

A panel of ten fishmeal industry experts is chosen. To cover different perspectives, experts from fishmeal producers, fishmeal traders, and academia are included in the panel. A list of the respondents participating in both rounds may be found in Table A3 in Appendix A.

[17] The definitions of the characteristics used in the survey can be found in Section A1 in Appendix A, and are, to a great extent, adapted from a similar survey conducted by Brorsen and Fofana (2001) on other types of commodities.

5. Empirical Results

This chapter will present the results from the empirical analysis of this thesis. First, in Subchapter 5.1, the results from the cointegration analysis will be presented. This presentation will include findings from both the unit root tests and the cointegration tests. Second, in Subchapter 5.2, the results from the Delphi survey will be presented. This presentation will include fishmeal measures estimated for the activeness of the cash market, homogeneity, vertical integration, and buyer concentration. The measures for the three latter variables are used in the probability prediction in Bekkerman and Tejeda's (2017) model. The results from this prediction will be presented in Subchapter 5.3, and will conclude the presentation of empirical results.

5.1 Results from Cointegration Analysis

The results from the cointegration analysis will provide an indication of fishmeal's degree of homogeneity and whether there are one or several separated fishmeal markets. To test for cointegration, it is first necessary to test for stationarity/non-stationarity by applying unit root tests.

5.1.1 Unit Root Tests

All available fishmeal price series, after being log-transformed, are tested for the presence of unit roots in levels and in first-difference. Both ADF, DF-GLS, and KPSS tests are applied on all series. Based on visual observation of the price series, the tests are executed with *constant* and *constant and trend*. The number of lags included in the test models is determined by the general-to-specific rule recommended by Hall (1992), with maximum lag length determined by Schwert's (1989) rule of thumb. The processes are also specified with monthly time dummies and a time trend, and adjustments for the El Niño phenomenon are explored. The El Niño adjustments did, however, not improve model specification.

To analyse the presence of unit roots, i.e. whether a series is non-stationary, the unit root tests are first applied on the level form of the price series and then on the first-differenced form of the price series.

A rejection of the null hypothesis of the ADF and DF-GLS tests and a failure to reject the null hypothesis of the KPSS test on the level series indicate that the series is stationary, i.e. $I(0)$. A failure to reject the null hypothesis of the ADF and DF-GLS tests and a rejection of the null hypothesis of the KPSS test on the level series indicate that the series is non-stationary and not $I(0)$.

A rejection of the null hypothesis of the ADF and DF-GLS tests and a failure to reject the null hypothesis of the KPSS test on the first-differenced series indicate that the series is stationary when first-differenced, i.e. $I(1)$. A failure to reject the null hypothesis of the ADF and DF-GLS tests and a rejection of the null hypothesis of the KPSS test in the first-differenced series indicate that the series is non-stationary when first-differenced and not $I(1)$.

In the event of indication of non-stationarity in both levels and first-differences, one should apply further differencing and investigate whether the series is integrated of a higher order than one. This was, however, not applicable to the series analysed in this thesis.

The results from the ADF, DF-GLS, and KPSS tests on the level and first-differenced price series are reported in Table 4 on page 49, where "Δ" indicates first-difference.

The null hypothesis of the ADF and DF-GLS tests is not rejected, and the null hypothesis of the KPSS test is rejected at the 1% significance level, for both *constant* and *constant and trend* for the level price series of Fishmeal Peru 68%, Fishmeal Peru 67%, and Fishmeal Peru 64%, indicating that these price series are non-stationary and not $I(0)$. For the first-differenced version of these price series, the null hypothesis of the ADF and the DF-GLS test is rejected at the 1% significance level, and the null hypothesis of the KPSS test is not rejected, for *constant* and *constant and trend*. This indicates that these price series are $I(1)$ and stationary when first-differenced.

For the price series Fishmeal Chile 68%, Fishmeal Iceland 71%, and Fishmeal Denmark 72%, the results from the unit root tests are more ambiguous.

The results from the KPSS tests indicate that the mentioned price series are non-stationary in levels and not $I(0)$. The null is rejected at the 1% significance level for Fishmeal Chile 68% and Fishmeal Denmark 72% for both *constant* and *constant and trend*. For Fishmeal Iceland 71%, the null is rejected at the 5% significance level for *constant*, and at the 1% significance level for *constant and trend*. Additionally, all series are indicated to be stationary in first-differences and $I(1)$.

The null hypothesis of the ADF test is rejected at the 5 % significance level for level Fishmeal Chile 68%, Fishmeal Iceland 71%, and Fishmeal Denmark 72% for *constant*, indicating that they are stationary in levels and $I(0)$. However, the null hypothesis is not rejected in the same test of the mentioned price series in levels for *constant and trend*, indicating that the price series are non-stationary. In addition, the ADF test also indicates that the price series are stationary in first-difference and $I(1)$, with a rejection of the null hypothesis at the 1% significance level for both *constant* and *constant and trend*.

The results from the DF-GLS test, which has been shown to be more powerful than the ADF test (Elliot, Rothenberg, & Stock, 1996), indicate that Fishmeal Chile 68%, Fishmeal Iceland 71%, and Fishmeal Denmark 72% are stationary in levels and $I(0)$ for both *constant* and *constant and trend,* with rejection of the null hypothesis at the 1% and 5% significance level, respectively. However, the same test also indicates that the mentioned price series are stationary in first-difference and $I(1)$, with rejection of the null hypothesis at the 1% significance level for both *constant* and *constant and trend*.

In summary, all tests indicate that the Peruvian price series are non-stationary in levels and $I(1)$, the KPSS test indicates that all price series are non-stationary in levels and $I(1)$, while the ADF test and the DF-GLS test give ambiguous results when applied to level non-Peruvian price series. The ADF and the DF-GLS tests do, however, concur when applied to first-differenced price series, indicating that the price series are in fact $I(1)$. The tests could be sensitive to the number of lags applied, and due to the ambiguous results from the level tests, and the overall concurrence and strong significance level in the first-differenced tests, there is strong belief of the presence of non-stationarity in levels and $I(1)$ across all price series. Thus, all price series will be treated as $I(1)$ in this thesis. It must, however, be noted that the belief of $I(1)$ is not as certain for the non-Peruvian price series as it is for the Peruvian price series.

The indication of $I(1)$ for all price series means that analysis of cointegration is applicable to all fishmeal price series.

Table 4: ADF, DF-GLS and KPSS Tests for Unit Roots

Variable	ADF		DF-GLS		KPSS	
	Constant	**Constant & trend**	**Constant**	**Constant & trend**	**Constant**	**Constant & trend**
FM Peru 68%	-2.210 (3)	-3.264 (3)	0.222 (3)	-2.284 (3)	10.900** (3)	1.390** (3)
ΔFM Peru 68%	-9.362** (2)	-9.324** (2)	-6.912** (2)	-4.815** (2)	0.136 (2)	0.056 (2)
FM Peru 64%	-2.405 (5)	-3.323 (5)	-0.081 (5)	-2.314 (5)	6.500** (5)	1.100** (5)
ΔFM Peru 64%	-7.902** (4)	-7.859** (4)	-6.782** (4)	-3.795** (4)	0.106 (4)	0.048 (4)
FM Peru 67%	-2.215 (3)	-3.229 (3)	0.196 (3)	-2.299 (3)	10.600** (3)	1.440** (3)
ΔFM Peru 67%	-9.220** (2)	-9.180** (2)	-8.228** (2)	-4.779** (2)	0.135 (2)	0.056 (2)
FM Chile 68%	-2.955* (4)	-3.028 (4)	-2.684** (4)	-2.991* (4)	0.857** (4)	0.594** (4)
ΔFM Chile 68%	-7.573** (2)	-7.567** (2)	-7.513** (2)	-7.520** (2)	0.078 (2)	0.079 (2)
FM Iceland 71%	-3.039* (6)	-3.076 (6)	-2.991** (6)	-2.991* (6)	0.488* (6)	0.289** (6)
ΔFM Iceland 71%	-6.971** (5)	-6.964** (5)	-6.890** (5)	-6.797** (5)	0.050 (5)	0.049 (5)
FM Denmark 72%	-3.011* (6)	-3.159 (6)	-2.980** (6)	-2.995* (6)	0.869** (6)	0.342** (6)
ΔFM Denmark 72%	-7.021** (4)	-7.013** (4)	-6.944** (4)	-6.897** (4)	0.056 (4)	0.057 (4)

Note: The table shows test statistics, significance levels and lags (in parenthesis). "FM" refers to "Fishmeal".
*** indicates 1% significance level, * indicates 5% significance level.*

5.1.2 Cointegration Tests

All available fishmeal price series, after being log-transformed, have been tested for bivariate cointegration with the Engle-Granger two-step method. The tests have been executed with *constant* and *constant and trend*.

The intercept in a regression between two price series can be interpreted as the long-run price difference between two commodities. This price difference will typically occur due to differences in transportation, tax and customs costs, or quality (for instance differences in protein concentration). The number of lags included in the test model is determined by the general-to-specific rule recommended by Hall (1992), with maximum lag length determined by Schwert's (1989) rule of thumb, as for the unit root tests. Generally, including many lags will affect the power of the test, i.e. weaken test results. A rejection of the null hypothesis in the Engle-Granger test indicates that the two tested price series are cointegrated. A failure to reject the null hypothesis indicates that there is no cointegration.

The results from the Engle-Granger tests on all price series, with combinations of all series as both dependent and independent variable in the regression, are summarised in Table 5. The Engle-Granger tests are run with combinations of all series as both dependent and independent variables, because the results can be conflicting. This is a weakness of the Engle-Granger test (Apostolos, 2007). In Table 5, green boxes represent a test indication of a cointegration relationship between two price series with at least 5% significance when either *constant* or *constant and trend* is applied, whereas red boxes represent a test indication of no cointegration. Complete results for both the *constant* and *constant and trend* tests, including the number of lags included, test statistic and significance level when relevant, are reported in Table B1 in Appendix B.

Table 5: Cointegration Matrix – Engle-Granger Tests

		Independent variable					
		FM Peru 68%	FM Peru 67%	FM Peru 64%	FM Chile 68%	FM Iceland 71%	FM DK 72%
Dependent variable	FM Peru 68%						
	FM Peru 67%						
	FM Peru 64%						
	FM Chile 68%						
	FM Iceland 71%						
	FM DK 72%						

Note: "FM" refers to "Fishmeal", and "FM DK 72%" refers to "Fishmeal Denmark 72%". Green boxes indicate a cointegration relationship, whereas red boxes indicate no cointegration relationship.

The null hypothesis in the Engle-Granger test is rejected for all possible bivariate combinations within the subgroup of Peruvian and Chilean origin fishmeal, indicating that these price series all have a bivariate cointegration relationship with each other. This result holds for all combinations of dependent and independent variables.

The null hypothesis is also rejected for the two possible bivariate combinations of Fishmeal Iceland 71% and Fishmeal Denmark 72%, indicating that these price series are cointegrated.

The null hypothesis is not rejected for any combinations of fishmeals from the subgroup of Peruvian and Chilean origin fishmeals and Fishmeal Iceland 71%, indicating that there is no cointegration between any of the fishmeals from the subgroup of Peruvian and Chilean origin fishmeals and Fishmeal Iceland 71%.

When Fishmeal Denmark 72% is used as independent variable, there is also no rejection of the null hypothesis for any combinations of fishmeals from the subgroup of Peruvian and Chilean origin fishmeal and Fishmeal Denmark 72%, indicating that there is no cointegration relationship between any of the fishmeals from the subgroup and Fishmeal Denmark 72%. When Fishmeal Denmark 72% is used as dependent variable, however, there are ambiguous and inconsistent test results. The null hypothesis is not rejected when testing Fishmeal Denmark 72% against Fishmeal Peru 64% and Fishmeal Chile 68%, indicating no cointegration relationship. However, the null hypothesis is rejected when testing Fishmeal Denmark 72% against Fishmeal Peru 68% and Fishmeal Peru 67%, indicating a bivariate cointegration relationship between these pairs. Since there are clear indications of cointegration between all series within the subgroup of Peruvian and Chilean origin fishmeals and the same between Fishmeal Iceland 71% and Fishmeal Denmark 72%, whereas there is also strong indication of no cointegration across the two subgroups, one should be very careful with putting any weight on the contradicting results. The ambiguous unit root test results for Fishmeal Denmark 72%, as discussed in Section 5.1.1, might explain why there are some ambiguous cointegration test results for this price series as well.

In summary, the Engle-Granger test results indicate that there exist two subgroups of cointegrated price series: a South American subgroup consisting of Peruvian and Chilean origin fishmeals, and a Nordic subgroup consisting of Icelandic and Danish origin fishmeals. The test results are also, except for some inconsistencies that might be explained, indicating that there are no cointegration relationships between any of the series across subgroups. The indication of two cointegrated subgroups of fishmeal price series has implications for our discussion of whether fishmeal is homogenous and for the assessment of the size of the fishmeal market, which are important success factors for futures contracts. More specifically, the results indicate that fishmeal might be homogenous in the South American and Nordic region, separately, and that fishmeal might have two separate markets. The exact derivations and implications of this indication are thoroughly explained in Chapter 6.

5.2 Delphi Survey Results

Measures of homogeneity (Hom), activeness of the cash market (ACM), vertical integration (VI), and buyer concentration (Con) for fishmeal are estimated through use of the Delphi method. An additional ACM measure is estimated using Bekkerman and Tejeda's (2017) method, as described in Section 4.4.1. The latter ACM measure and Delphi measures of homogeneity, vertical integration, and buyer concentration will be used when predicting the probability of fishmeal futures contract existence.

While several versions of the Delphi method exist (e.g. Brorsen & Fofana, 2001; Helmer, 1967), the survey method applied in this thesis mostly follows the approach of Brorsen and Fofana (2001), as described in Section 4.4.2. Experts are surveyed over two rounds. Bekkerman and Tejeda (2017) also adapts Delphi measures from Brorsen and Fofana (2001), except for measures of ACM. This measure is estimated using the method described in Section 4.4.1.

Although ten experts were invited to take part in the survey, only seven completed both rounds. The results, presented in Table 6, are based on responses from these seven experts. The questions answered by the respondents, in full, as well as a list of the chosen respondents, may be found in Section A1 and Table A3 in Appendix A, respectively. Brorsen and Fofana (2001) provides respondents with average measures for each variable, the associated standard deviation and the associated one standard deviation range after the first round. Due to a broader range than expected in the responses gathered in the first round, respondents in our survey were also provided with the median for each variable in the second round. The rationale for this is that it was believed to improve the accuracy and "correctness" of the final responses gathered in the second round.

Table 6 shows averages (with the corresponding standard deviation in parenthesis), one standard deviation ranges, medians, and conclusions of high or low degree of a characteristic for each variable in both rounds. The ranges are rounded to integers, which was also done in the survey.

Table 6: First and Second Round Results from Delphi Survey on Fishmeal

	Hom	**ACM**	**VI**	**Con**
Average Round 1	4.86 (1.55)	4.43 (1.50)	6.29 (2.12)	7.00 (2.00)
Range	3-6	3-6	4-8	5-9
Median Round 1	5	5	7	8
Conclusion Round 1	Low/High	Low/High	High	High
Average Round 2	4.71 (0.76)	3.86 (0.69)	6.43 (1.40)	7.43 (1.51)
Range	4-5	3-5	5-8	6-9
Median Round 2	5	4	7	8
Conclusion Round 2	Low/High	Low	High	High

Note: A "High" or "Low" conclusion is determined by the average and median measures. "Low" = {1, 2, 3, 4} and "High" = {5, 6, 7, 8, 9, 10}, following Bekkerman and Tejeda (2017). *Standard deviations are shown in the parentheses.*

In the first round, homogeneity and activeness of the cash market show conflicting results depending on whether the conclusion is based on the average or the median measure. This is due to a few extreme responses in the lower range, while the majority of responses are around 5. The ranges for these variables are relatively narrower than what is the case for the measures of vertical integration and buyer concentration. Some extreme responses in the lower range also affect the average measures in these cases, with the majority of responses lying above the average. Based on the results from the first round, homogeneity and activeness of the cash market may be said to be somewhat uncertain, while vertical integration and buyer concentration may be said to be high.

In the second round, the respondents are given the exact same questions. The respondents whose answers in the first round fall out of the range are asked to either justify their answer or change it to lie within the range. All respondents changed their answer to fit inside the range. Consequently, a reduced standard deviation is seen for the variables after the second round, which leads to a more precise consensus estimate for each variable. While the average measures of homogeneity and activeness of the cash market are reduced, the averages of vertical integration and buyer concentration are increased. The median for each variable remains the same, except for activeness of the cash market. This median is reduced from 5 to 4, implying a consensus on low activeness in the fishmeal cash market. Homogeneity is still uncertain after the second round, due to conflicting results between the average and the median. However, the respondents reach consensus on high vertical integration and buyer concentration.

While a time-dependent measure of the activeness of the cash market is estimated using Bekkerman and Tejeda's (2017) approach in Subchapter 5.3, homogeneity, vertical integration and buyer concentration are assumed to be time-invariant.

5.3 Bekkerman & Tejeda: Probability of Fishmeal Futures Contract Existence

Through Bekkerman and Tejeda's (2017) first-stage model, the probabilities of existence of a futures contract for fishmeal in each year from 2005 to 2017 are predicted. An average probability for all years, in line with Bekkerman and Tejeda's (2017) presented results, is also predicted. The results, presented in Table 7[18], show that the probability of a futures contract existing for fishmeal, according to the model, equals zero percent every year. This also holds true for the average probability. The main drivers of these results are that the fishmeal market has been defined to have a high degree of vertical integration and buyer concentration. Had the fishmeal market been defined to have a low degree of vertical integration and buyer concentration, the average probability would have been 99.95 percent. The results and the model will be thoroughly discussed in Subchapter 6.1.

[18] For a description of how the measures are estimated, the reader is referred to Section 4.4.1.

Table 7: Results from Applying Bekkerman and Tejeda's (2017) Probability Model on Fishmeal

	Commodity market components						**Futures market components**		**Output**	
Year	**Hom**	**VI**	**Con**	**CV**	**ACM**	**Size**	**XVol**	**RR**	**Pred.**	**Predicted prob.**
2005	Low	High	High	7.24	13.76	15.42	12.20	0.99	-4.74	0.00%
2006	Low	High	High	17.25	9.69	15.45	12.77	0.92	-5.02	0.00%
2007	Low	High	High	11.30	10.13	15.45	12.84	1.00	-4.89	0.00%
2008	Low	High	High	8.20	10.63	15.46	12.98	0.97	-4.69	0.00%
2009	Low	High	High	20.07	5.42	15.26	12.92	0.97	-5.14	0.00%
2010	Low	High	High	9.37	8.19	15.53	13.17	0.98	-4.55	0.00%
2011	Low	High	High	12.62	6.96	15.36	13.29	0.99	-4.91	0.00%
2012	Low	High	High	16.40	7.02	15.39	13.17	0.97	-5.04	0.00%
2013	Low	High	High	18.04	5.63	15.31	13.05	0.99	-5.09	0.00%
2014	Low	High	High	15.97	7.56	15.36	13.18	0.94	-5.02	0.00%
2015	Low	High	High	12.75	10.08	15.32	13.33	0.96	-5.24	0.00%
2016	Low	High	High	6.13	10.02	15.40	13.40	0.98	-4.76	0.00%
2017	Low	High	High	2.96	13.60	15.35	13.43	0.98	-4.98	0.00%
Average probability									**0.0001 %**	

Note: The ACM measure presented for year 2005 represents the average ACM measure for the last 26 weeks of that year. This is because our data only includes cash prices from the beginning of 2005 onwards. "Pred.." is the prediction of the model, while "Predicted prob." is the predicted probability (prediction of the model converted with a normal CDF).

The measures for homogeneity (Hom), vertical integration (VI), and buyer concentration (Con) refers to the Delphi results, which were presented in Subchapter 5.2.

The coefficient of variation (CV) represents a measure of the volatility in fishmeal cash prices[19] and is estimated in line with the procedure of Bekkerman and Tejeda (2017). The size of the variable varies between 2.96 (2017) and 20.07 (2009), where a higher CV means a higher cash price volatility.

For comparability with Bekkerman and Tejeda (2017), the ACM measures presented in Table 7 follow its ACM estimation approach, and represent the expected number of no weekly price changes. A high ACM measure is thus equivalent to low activeness in the cash market. It should, however, be noted that in the prediction of the probability, for each year, 26 minus the ACM measure is used. The findings in Table 7 show that the highest expected number of no price changes is found in 2017, with an ACM of 13.60, if the imprecise measure for year 2005 is excluded[20]. The lowest measure is found in 2009, with an ACM of 5.42.

In terms of residual risk (RR), our analysis show that corn provided a marginally better cross-hedge efficiency than soybean meal[21]. The measures of residual risk in Table 7 therefore represent the price risk that could not be hedged away with a static minimum-variance optimal hedge ratio strategy using corn futures. The lowest residual risk is seen in 2006, with a RR calculated to 92 percent. The highest is seen in 2007, with a RR of 100 percent.

The measures calculated for the natural log of the market size (Size) and the natural log of the volume of the cross-hedge contract (XVol) are not very revealing on a stand-alone basis. However, we see that the market size measure is fairly stable over the years, with the highest and lowest measures seen in 2010 and 2009, respectively. In terms of cross-hedge contract volume, Table 7 suggests an upward trend. The highest measure is seen in 2017, while the lowest is seen in 2005.

Comparable measures found for the commodities in Bekkerman and Tejeda's (2017) paper are presented in Table 8, together with the measures for fishmeal. The measures for fishmeal will be subject to thorough discussion and comparison in Chapter 6. The adapted measures for

[19] The fishmeal cash price series applied in this analysis is Fishmeal Peru 68%.

[20] See note in Table 7 for further explanation.

[21] Coefficients of determination from regressing soybean meal and corn futures prices on fishmeal prices, as per the method presented in the Subsection Risk Reduction Through Futures Cross-Hedging in Section 4.4.1, are presented in Table A6 in Appendix A.

the commodities from Bekkerman and Tejeda (2017) represent 2007-2012 averages, while the measures for fishmeal represent the 2005-2017 average[22].

Table 8: Variable Measures for Commodities Obtained from Bekkerman and Tejeda (2017) and Average Measures for Fishmeal

Commodity	Futures market	Hom	VI	Con	CV	ACM	Size	Xvol	RR
Apples	No	Low	High	High	7.68	17.91	14.82	7.41	0.98
Barley	No	High	Low	Low	12.95	11.38	7.66	11.72	0.37
Broilers	No	High	High	High	5.81	9.06	16.94	10.20	0.94
Cheese	Yes	High	Low	High	7.27	4.43	14.93	-1.33	0.41
Corn	Yes	High	Low	Low	11.81	0.35	11.60	10.77	0.22
Dry milk	Yes	High	Low	High	11.23	5.68	13.54	-1.33	0.17
Dry whey	Yes	High	Low	High	16.43	8.28	13.16	-1.33	0.73
Eggs	No	High	High	High	19.89	8.77	18.32	10.20	0.96
Fed cattle	Yes	Low	High	High	4.42	0.14	16.45	11.72	0.41
Hogs	Yes	High	High	High	11.12	0.03	16.51	10.21	0.50
Oranges	No	Low	High	High	14.49	8.01	16.03	7.42	0.96
Pinto beans	No	High	Low	High	10.92	17.29	13.18	9.23	0.99
Potatoes	No	Low	Low	High	17.14	8.01	16.89	10.77	0.87
Rice	Yes	High	Low	High	8.55	18.02	16.15	10.77	0.94
Sorghum	No	High	Low	Low	14.98	0.21	8.03	11.72	0.04
Soybeans	Yes	High	Low	Low	15.16	0.18	10.15	10.20	0.22
Soybean oil	Yes	High	Low	Low	11.47	0.02	16.04	8.99	0.12
Soybean meal	Yes	High	Low	Low	12.68	0.16	17.47	11.23	0.30
Sunflower seed	No	High	Low	High	11.45	12.53	14.15	10.49	0.20
HRS wheat	Yes	High	Low	Low	18.66	0.18	8.40	9.22	0.25
HRW wheat	Yes	High	Low	Low	18.53	0.23	8.97	10.76	0.10
SRW wheat	Yes	High	Low	Low	19.99	0.16	8.11	9.22	0.20
Fishmeal	-	Low	High	High	12.18	9.13	15.39	13.06	0.97

Source: Bekkerman and Tejeda (2017) and collected measures for fishmeal

[22] For some measures, for instance of CV, the comparability of price series of different time periods might be low. However, we do not believe that our extended period of price data for fishmeal causes any problems in the comparison with the presented commodities.

6. Discussion

In Subchapter 6.1, the results of applying Bekkerman and Tejeda's (2017) model to fishmeal, as well as the model, will be discussed. In Subchapter 6.2, factors related to the underlying commodity market and other futures contracts will be discussed with relation to fishmeal. Subchapter 6.3 will discuss the users of a potential fishmeal futures contract and aspects related to the exchange introducing it. In Subchapter 6.4, optimal design of a potential fishmeal futures contract will be discussed. Finally, Subchapter 6.5 will summarise the discussion.

6.1 The Bekkerman & Tejeda Model Applied on Fishmeal

As presented in Subchapter 5.3, Bekkerman and Tejeda's (2017) model predicts a zero percent probability of existence of a futures contract for fishmeal both on average and for each year in the 2005-2017 time period. In other words, it perfectly predicts the real case of a non-existent fishmeal contract in this time period. The main reason for why fishmeal achieves a zero percent probability is that buyer concentration and vertical integration, according to the results from the Delphi survey on fishmeal, are present in the fishmeal market. Had the fishmeal market been defined to have a low degree of buyer concentration and vertical integration, the average probability of existence of a futures contract would have increased to 99.95 percent.

The model does not provide us with ground-breaking results. Despite the accuracy of the model, there are issues that should be addressed.

First, we have problems with accepting the estimated negative effects that residual risk and volatility have on the probability of existence of a futures contract. Bekkerman and Tejeda's (2017) model predicts the probability of *current existence* of a futures contract for a given agricultural commodity. This may not be an ideal way of predicting the probability of a *potential* futures contract succeeding, because measures for commodities with existing and potential, but still viable, futures contracts may be very different. Normally, one would expect that high residual risk and volatility have a positive effect on the viability of a potential futures contract. Because the model conflicts with this view, we have some scepticism about whether this model is ideal for evaluating a potential futures contract.

Second, we also believe that the model overlooks the effect *market value* has on the probability of existence of a futures contract. The market size variable only captures tonnes produced, thus neglecting the fact that commodities such as for example oranges and pinto beans may have widely different prices per tonne. Our hypothesis is that market value has a positive effect on the probability of existence of a futures contract, because market value can be seen as a proxy for how much public, analytical and commercial interest a commodity receives and because higher market value normally should entail a higher willingness-to-pay for sufficient transaction costs to sustain basic infrastructure for a futures contract. To exemplify, the average price of Peruvian origin Super Prime fishmeal was USD 1 476 per tonne in 2017, while the average futures price of soybean meal was USD 348 per tonne, implying that the production of soybean meal must be approximately 4.2 times the production of fishmeal for the two commodities to have equivalent market values.

Because of the addressed issues, we believe that one cannot solely rely on the quantitative result from Bekkerman and Tejeda's (2017) model and conclude that a futures contract for fishmeal is not viable. Due to this, we will thoroughly discuss the success factors included in the model and other success factors identified by the literature before arriving at a conclusion on the viability of a futures contract for fishmeal.

6.2 The Underlying Commodity Market and Other Futures Markets

6.2.1 Uncertainty

Uncertainty is an obvious reason to participate in, and to establish, a futures market, and it is also a consistently mentioned criteria in papers discussing the success of futures contracts (Black, 1986; Carlton, 1984).

The coefficient of variation (CV), a common measure for volatility, is expected to be positively related to the success of a futures contract, because more uncertainty should stimulate parties looking to hedge or speculate. Despite this, empirical models from papers on the success of futures contracts show conflicting results. Brorsen and Fofana (2001) finds a positive, significant relationship between CV and futures contract trading volume and open interest. Bekkerman and Tejeda (2017), on the other hand, finds a negative, significant relationship between CV and the probability of a futures contract existing for an agricultural commodity. Additionally, the paper finds a negative, but not significant, relationship between CV and trading volume. The results of Brorsen and Fofana (2001) are more in line with expectations, and Bekkerman and Tejeda (2017) argues that agricultural commodities with existing futures contracts have low volatility due to the fact that they have futures contracts, i.e. that their findings may be subject to the chicken or egg causality dilemma.

Comparing the CV of fishmeal and agricultural commodities with successful futures contracts before the initial listing of the successful contract, could overcome the chicken or egg causality dilemma. However, Black (1986) argues against comparisons between volatilities of different time periods. Comparing the CV of a commodity with a recently introduced, successful futures contract could be a solution, but it is hard to judge whether a new contract has achieved success without having a track-record.

Due to these issues, comparing CVs of fishmeal cash prices with CVs of other agricultural commodities found in Bekkerman and Tejeda (2017) have been deemed to be the best method. The CVs are calculated on prices from January 2007 to September 2012 of agricultural commodities both with and without futures contracts. We do not believe that any changes greatly affecting the price volatility of the agricultural commodities have occurred after September 2012. Nor do we believe that our extended period of price data for fishmeal leads to any conflicting results. CVs of fishmeal for the period 2005-2017 is thus compared to those of the agricultural commodities.

The average yearly CV for fishmeal for the 2005-2017 period is 12.18[23] and the full-period CV is 29.10. Comparing the average yearly CV for fishmeal with the CVs of agricultural commodities presented in Bekkerman and Tejeda (2017), fishmeal CV places in between the commodities both with and without futures contracts. The lowest CV for a commodity with a futures contract, fed cattle, is 4.42, whereas the highest, SRW wheat, is 19.99. These CVs are also the extreme observations when commodities without futures contracts are included. Based on this, the volatility of fishmeal, although not the highest in the sample, seems to be on par with that of agricultural commodities with futures contracts.

[23] In line with Bekkerman and Tejeda's (2017) model, the average CV is calculated as the average of each yearly CV in the period under investigation. See Table 7 and Table 8 in Subchapter 5.3 for yearly CVs and the average yearly CV, respectively.

Based on comparison alone, it is still difficult to conclude on whether the fishmeal market has sufficient uncertainty to justify the establishment of a futures contract. A further discussion of the nature of uncertainty in the fishmeal market is warranted.

Fishmeal price changes are highly dependent on the variance in, and expected future levels of, supply. Demand has a more constant or increasing character and is thus more certain. As mentioned earlier, the supply of fishmeal relies heavily on the Anchoveta catches in Peru, which again depends heavily on the El Niño weather phenomenon, as well as fishing quotas (Sherling, 2018).

The El Niño weather phenomenon (and somewhat the La Niña, which may also have consequences for landings of Anchoveta) is unpredictable with irregular frequency. The El Niño weather phenomenon, following the definition of National Oceanic and Atmospheric Administration (NOAA), is said to first occur after seven consecutive months of sea surface temperatures 0.5 degrees above the normal (Null, 2018). The La Niña weather phenomenon follows the same definition, but with 0.5 degrees below the normal. Because of the slow nature of the clarification of whether there is an El Niño occurrence or not, it seems reasonable to expect that these weather phenomena are reflected in spot prices gradually. Consequently, prices will, at least to some extent, reflect these phenomena before the occurrence is certain as per NOAA's definition. Additionally, large shifts in prices are also expected to be seen if market participants discover that the weather has had a different than expected effect on the availability of raw material.

The quotas are not as uncertain, but landings rarely fill them. Between April 7 2018 and May 9 2018, less than 50% of the total Anchoveta quota in Peru's north-centre waters was landed (Undercurrent News, 2018). A great part of the reason for this is likely to be the La Niña of 2017, which caused a "high presence of juveniles and a high dispersion of the resource", according to Rossana Ortiz Rodriguez, CEO of Peruvian fishmeal producer Exalmar (Rodriguez, 2018). Lower catches than expected, no matter the reason, result in price increases. On the contrary, with catches being higher than expected, prices decrease. Landing uncertainty might not always be reflected in very high volatilities short-term. Within some years, prices appear to move considerably in one direction (perhaps in line with strengthened beliefs or disbeliefs of El Niño occurrence), and then return to a slightly higher or lower level than the price twelve months earlier. In other years, prices appear to experience a considerable shift within a short time period, for instance due to a mismatch between landings of raw material and the belief or disbelief of the severity of El Niño. Even when the calculated CV is quite low, great differences in price may have occurred. To exemplify this, one can look at CVs in 2016 and 2017, which were 6.13 and 2.96, respectively. These are the two lowest CVs in the 2005-2017 time period. Even with these low CVs, the differences in the fishmeal price throughout a year could be defined as high. In 2016, the fishmeal price per tonne[24] varied between USD 1 550 and USD 1 900, with an average price equal to USD 1 682. In 2017, the price varied between USD 1 395 and USD 1 555, with an average price equal to USD 1 476**.** In terms of dollars per tonne, the differences between the lowest and highest prices are substantial, and this dynamic is not captured by looking at CV alone. For a fishmeal producer, selling at prices in the lower band will have dramatic effects on both revenues and profits.

It is apparent that a lot of the price risk in the fishmeal market hinges on the El Niño phenomenon. Due to the unpredictability of the occurrence of this phenomenon, price fluctuations may be less frequent once market participants know whether it has occurred or not and the severity of it. In other words, prices are expected to be less uncertain as long as the market is certain of the El Niño effect. In periods where market participants are uncertain about the El Niño effect, however, price risk is expected to be higher. We hypothesise that market participants will have very high demand for hedging price risk in such uncertain periods, because it has the potential to profoundly affect profitability. To our knowledge, a standardised El Niño weather derivative does not exist[25].

In summary, we believe that, although a comparison of CVs gives somewhat unclear indications on whether the uncertainty in the fishmeal market justifies a futures contract, the fishmeal market is indeed an uncertain market, and there should be high demand for mitigating price risk.

6.2.2 Product Homogeneity

Estimations of Bekkerman and Tejeda (2017) indicate that homogeneity has a positive, insignificant effect on the existence of a futures contract, and a positive, significant effect on trading volume. In fact, homogeneity is one out of two significant cash market characteristics

[24] The Fishmeal Peru 68% price series is applied.

[25] It is of course possible to enter into a derivative agreement in the over-the-counter market.

that affect futures contract trading volume. These results imply that homogeneity, although not necessarily the most important factor for futures contract existence, is important for the activity in, and thus success of, a futures contract. Brorsen and Fofana (2001) also finds that homogeneity has a positive, significant effect on trading volume and open interest, supporting the importance of homogeneity. Both Bekkerman and Tejeda (2017) and Brorsen and Fofana (2001) measure homogeneity as the effectiveness of the grading system for a commodity, through the Delphi method. This allows for both naturally homogenous commodities and less naturally homogenous, but effectively graded, commodities to have a high degree of homogeneity. This definition is also used in our measurement of this factor.

Results from our Delphi survey on fishmeal show that there are conflicting opinions regarding the homogeneity of fishmeal, with the mean opinion barely leaning towards that it is heterogeneous. It is therefore difficult to conclude on the degree of homogeneity of fishmeal solely based on this quantitative approach. We theorise that the surveyed panel of experts may indeed be of different opinions, both on the final conclusion on heterogeneity and on the degree thereof. This is due to the fact that some respondents represent companies that might be interested in positioning their product as a premium, non-commodity product, while others are not. The panel has, in any case, been deemed to give a balanced and fair representation of the fishmeal market, and the ambiguity should therefore not be dismissed.

While the Delphi method hinges on the opinions of industry experts, our cointegration results offers a more objective view. As explained in Section 4.3.2, existence of a cointegration relationship between two time series means that there is a long-run equilibrium relationship between the two series, i.e. that they will follow each other closely in the long-run. Cointegration is also a prerequisite for the existence of the law of one price (LOP) (Goodwin, 1992). The LOP states that substitute commodities cannot diverge in price without arbitrage opportunities arising, and that efficient markets ensure that such opportunities will be discovered and exploited quickly (Goodwin, 1992). This will in turn ensure that prices follow a close long-run relationship. There are methods for formally testing the presence of the LOP[26], but we find this to lie outside the scope of this thesis. Since cointegration is a prerequisite for the LOP, cointegration analysis can be utilised to filter out price series where

[26] Asche and Tveterås (2004) and Langdalen (2017) have, for example, tested for the presence of the LOP among fishmeal and soybean meal markets, and in the global vegetable oil market, respectively.

the LOP relationship definitely does not hold, i.e. to filter out definite heterogeneous commodities or grades. We therefore use our cointegration results as an indicator of whether fishmeal is homogeneous.

Our cointegration results indicate that all fishmeal prices are cointegrated within the two submarkets of South America and the Nordics, separately, but that there is no cointegration relationship between prices across them. This has some interesting implications for the discussion on whether fishmeal is homogenous or not.

The fact that South American and Nordic fishmeal prices are separately cointegrated indicate that there is a long-run equilibrium relationship between prices within the two submarkets. This implies that within the two submarkets, prices of different qualities of fishmeal have a distinct, although possibly trending, relationship. One can infer from this that buyers and sellers acknowledge a grading system and agree on a distinct price differential between different grades. This speaks in great favour of fishmeal being homogenous through the existence of an effective grading system in South America and in the Nordics, separately.

The fact that we find no cointegration relationships between South American and Nordic fishmeals speaks against the existence of geographic homogeneity. This result is a bit surprising, but three explanations are plausible.

First, the result may indicate that fishmeal supply and demand factors are separate for South America and the Nordic region. South American fishmeal is in large reduced from Anchoveta, which has a very volatile supply due to the El Niño weather phenomenon, whereas Nordic fishmeal is based on other species caught in waters that are not exposed to the El Niño weather phenomenon. If the LOP holds, differences in raw material supply in the two markets should, however, not be an issue – different prices for the same good arising from supply issues, quality held constant, will lead to arbitrage opportunities. These will quickly be exploited, and prices will fall back in line.

Second, the LOP assumes that no frictions are present. It is, however, hard to argue that the global fishmeal market is free of these. Frictions such as taxes, customs and transportation costs may separate South American and Nordic fishmeal, homogenous or not. According to Sherling (2018), fishmeal prices are strongly linked after being adjusted for protein content and transportation costs, which supports the explanation that frictions may be the reason for why we find no cointegration across the two submarkets. This nuance might not be visible in our Delphi results.

Third, if the friction explanation is not the case, it could be that South American and Nordic fishmeals are non-substitutable due to differences in characteristics, for example arising from differences in production methods or species used as raw material. However, Sherling (2018) does not lend support to such an explanation.

To verify that the grading and the corresponding characteristics of fishmeal are consistent across different producers and geographies, specifications of Super Prime, Prime and Standard fishmeal are collected from four separate producers. Detailed specifications[27] are listed in Tables B2, B3, B4 and B5 in Appendix B. All specifications agree, with some minor variations, on the definitions of Super Prime, Prime and Standard fishmeal. The insight from this limited sample speaks in favour of the existence of an effective grading system for fishmeal, i.e. that it can be defined as homogenous. Homogeneity is also supported by Roheim, Asche and Santos (2011), which states that fishmeal is fairly homogenous.

In summary, the results from the Delphi survey, although ambiguous, point toward fishmeal being heterogeneous, while our cointegration results point toward the existence of an effective grading system in South America and in the Nordics, separately. Additionally, a sample of fishmeal producers agree on detailed specifications of different grades, and some industry insiders have also stated outright that fishmeal is homogenous. Based on these results, we are of the opinion that fishmeal, at least separately in South America and in the Nordics, is a homogenous commodity. If market frictions are the underlying reasons for our finding of existence of two fishmeal submarkets, fishmeal is a homogenous commodity both with respect to geography and quality.

6.2.3 Size of the Cash Market

Bekkerman and Tejeda (2017) finds the size of the cash market, measured by total production in tonnes, to have a positive, significant effect on the probability of futures contract existence. The relationship between the size and contract volume is also found to be positive, but not

[27] The specifications show that the content of protein, fat, moisture, salt, sand, FFA (free fatty acids), TVN (total volatile nitrogen), histamines, and antioxidants seem to be important measures that describe a given grade.

significant. The positive relationships are in line with Brorsen and Fofana (2001), which finds a positive, significant relationship with both contract volume and open interest. A larger cash market should increase the probability of futures contract success.

Log-transformed fishmeal production measures, reported in Table 7 in Subchapter 5.3, range between a minimum of 15.26 (2009) and a maximum of 15.53 (2010). Compared to the measures Bekkerman and Tejeda (2017) finds for other agricultural commodities, presented in Table 8 in Subchapter 5.3, the average measure for fishmeal, 15.39, seems sufficient for a potential fishmeal futures contract to be successful.

However, two important problems must be addressed. The first is raised by the interpretation of the cointegration results. These results reveal that there is no long-term equilibrium relationship between fishmeal prices across South America and the Nordics[28]. If this is indeed the true relationship, it may have great consequences for a potential futures contract. The reason is that, depending on what prices are fed into the settlement price index, one of these fishmeal submarkets might not be able to achieve a satisfying risk reduction through use of the contract. However, optimal construction of the fishmeal price index might help overcome this. Then, it will not be relevant to view fishmeal as having two completely separated submarkets.

The second important issue is related to the supply of fishmeal. The two extreme log-transformed size measures for fishmeal mentioned above are equivalent to 4 244 million tonnes and 5 551 million tonnes[29], respectively, which must be said to constitute a great variation in production. Although such variation is not the norm, there is still considerable uncertainty related to production level. Most fishmeal producing countries seem to have quota systems, which reduces the risk of excessive fishing on the forage fish used in production. On the other hand, future increases in landings seem less likely than decreases. While prices may also increase if supply decreases, the total value of the cash market may be negatively affected.

[28] Some of the cointegration results were ambiguous. See Subchapter 5.1.

[29] See Figure 3 in Chapter 2 for the size of both production of the top ten fishmeal producing countries and global production, between 2005 and 2017.

Bergfjord (2007) suggests that the size of the cash market could be of lower importance than other factors for commodities with medium sized cash markets. Table 8 in Subchapter 5.3 also shows that average global production of fishmeal in the 2005-2017 time period is larger than that of several other commodities that sustain futures markets. While some of these futures markets have support markets[30], which is argued to increase the probability of success (Bekkerman & Tejeda, 2017), comparison with these commodities speaks in favour of the fishmeal cash market being sufficiently large to warrant a futures contract.

Although there are some uncertainties and challenges related to the size of the fishmeal cash market, we do not believe that these are strong enough to discourage the establishment of a fishmeal futures contract, all else equal.

6.2.4 Activeness of the Cash Market

Bekkerman and Tejeda (2017) finds that a high degree of activeness in the cash market has a positive, significant effect on both the probability of futures contract existence and contract volume. Brorsen and Fofana (2001) concludes that high activeness of the cash market is a necessity for a futures contract to exist, while other characteristics are more important to the success of a contract once it exists.

With regards to fishmeal, results from both the Delphi survey and the method of Bekkerman and Tejeda (2017) indicate that the fishmeal cash market has a low degree of activeness. This is not very surprising. The catches of the raw material, and subsequent production, are restricted to short seasons, and due to strong demand, a large portion of fishmeal trading happens within and shortly after these seasons. This market dynamic will lead to fragmented trading throughout a year, with quotes of bids and offers happening less frequently out-of-season. Within and shortly after seasons, however, the activeness of the fishmeal market is believed to be relatively higher[31]. On another note, the fishmeal market does not have an organised marketplace such as regularly held auctions, and producers often sell their products on uncleared forward contracts (Sherling, 2018). Assuming that the extensive use of forward

[30] Support markets are futures markets for "goods that are jointly produced and/or marketed" (Bekkerman & Tejeda, 2017, p. 177).

[31] It is unclear whether our Delphi survey has captured the activeness on a general basis, or within and shortly after seasons, as it was not specified in the question.

contracts leads to less market interaction where prices are bid and quoted, both of these factors lead to lower cash market activity. To conclude, several factors speak in favour of the fishmeal cash market having low activity in a period of a year. In and shortly after seasons, though, activity may be comparatively higher.

6.2.5 Vertical Integration and Buyer Concentration

The results from Bekkerman and Tejeda (2017) indicate that buyer concentration and vertical integration have a negative, significant effect on futures contract existence, and that they both are of relatively high importance compared to other factors. Bekkerman and Tejeda (2017) excludes vertical integration and buyer concentration when estimating trading volume, because these variables are used as exclusionary restrictions. Brorsen and Fofana (2001), however, finds that a high degree of buyer concentration has a negative, significant effect on trading volume and open interest, which is in line with expectations. Surprisingly, its results show that a high degree of vertical integration has a positive, significant effect on trading volume and open interest. This result may, however, be explained. Brorsen and Fofana (2001) states that its sample measures of vertical integration and buyer concentration are highly correlated, with a correlation coefficient of 0.777. In other words, high vertical integration and high buyer concentration, and vice versa, very often coincide. This may lead to a multicollinearity problem, which could have been avoided if the two variables were pooled to one variable. This explanation, which should be noted is not offered in the paper, makes sense, because the pooled parameter estimates of vertical integration and buyer concentration altogether have a negative value, i.e. indicate that lower degrees of vertical integration and buyer concentration have a positive effect on trading volume and open interest.

It is possible to quantitatively measure both buyer concentration, e.g. by the Herfindahl-Hirschman Index (Investopedia, 2018), and vertical integration (see Ponomarenko & Sergeev, 2016). Common for these methods is that it is very time-consuming, or perhaps even impossible, to collect and compile the necessary data for the fishmeal market, because it is a very geographically fragmented, little analysed and non-transparent market. Therefore, the Delphi survey is the only quantitative method used to quantify buyer concentration and vertical integration in this thesis. Our Delphi results show that industry experts concur that the fishmeal market both has a high degree of buyer concentration and vertical integration.

That the fishmeal market is perceived as vertically integrated is not a very surprising result. Due to, among other, the scarcity and volatility of raw material supply, control of the supply chain may be the only way to mitigate raw material supply risk. Additionally, because there are no effective hedging opportunities in the raw material or fishmeal market today, vertically integrating raw material sourcing, fishmeal production, feed production, and in some cases also aquaculture, can offer reduction of price risk. There are several examples of such forms of vertical integration in the industry. Tveterås, Paredes and Peña-Torres (2011) states that in 2009, the seven largest fishmeal producers in Peru controlled 50% of the Anchoveta fishing fleet. To exemplify this tendency, the largest fishmeal producer in the world, the Peruvian company TASA, controls 49 vessels and 26% of the Peruvian national Anchoveta quota (TASA, 2018). There are also examples of vertical integration in the value chain from raw material sourcing up to feed production and even aquaculture. In 2017, Cooke Aquaculture, a Canadian salmon farming and seafood conglomerate, acquired Omega Protein (Smith, 2017). Omega Protein catches menhaden, a pelagic species, and reduces it to fishmeal and fish oil. The Faroe Islands based salmon farming company Bakkafrost also controls Havsbrún (Bakkafrost, 2018). Havsbrún produces both fishmeal, fish oil and fish feed, but does not control vessels or raw material quotas. There are, however, an exception to the tendency of vertical integration in the fishmeal market. In Norway, regulation forbids landing facilities and fishmeal producers to control quotas of, among other, pelagic species, effectively hindering vertical integration (Lov om førstehandsomsetning av viltlevande marine ressursar, 2013).

It is not very surprising to learn that industry experts perceive the fishmeal market to have a high degree of buyer concentration, either. According to Tveterås et al. (2011), in Peru, the seven largest fishmeal producers accounted for 80% of the fishmeal production in 2009, telling a tale of a concentrated supply side in the country. Additionally, according to the industry organisation IFFO, their over 200 members, from both the supply and demand side, account for over 50% of global fishmeal and fish oil production, and 75% of global trade (IFFO - The Marine Ingredients Organisation, 2018). These examples speak in favour of a concentrated market especially on the supply side, but somewhat also on the demand side.

6.2.6 Storability

Both Bekkerman and Tejeda (2017), Bergfjord (2007), and Black (1986) mention storability as a factor contributing to the success of a futures contract. Black (1986) argues that because many futures contracts obligate a seller to deliver a specific commodity at a specific date, storability offers the possibility for the seller to buy and store the commodity to satisfy this obligation. It also argues that the storability has become less restrictive for futures contract success with time and that technology, e.g. refrigeration, has made the factor less relevant. Bergfjord (2007) agrees with these insights and adds that storability is less of an issue today with modern transportation and the possibility of cash-settled contracts. Additionally, it mentions that the flexibility that storability adds to buying and selling open for arbitrage opportunities. In turn, this helps securing a close relationship between spot and futures prices. With this in mind, we believe that storability is a plus, but not at all a necessity, for the success of a futures contract. The success of salmon and electricity futures contracts, which are highly perishable commodities, are good examples of storability not being a necessity[32].

According to an industry insider, the standard expiry date of fishmeal is set to 12 months after production, but there is zero to negligent loss in quality for up to more than two years if it is stored in the right conditions (Sherling, 2018). Storage both in bulk, storage sheds and silos are commonplace in the industry (FAO, 2018c). All available information speaks in favour of fishmeal being a storable commodity. It must be noted, though, that long-term storage by fishmeal producers is not common due to high and immediate demand for the scarce supplies of fishmeal. This dynamic in the market is illustrated by FAO (2018c), which states that, in unfavourable marketing and shipping conditions, storage capacity sufficient to hold 30 days of production may be required. The fact that immediate consumption and processing, rather than storage, is commonplace makes the storability factor less relevant.

6.2.7 Free Flow of Information and Goods

Bergfjord (2007) argues that free flow of information and goods is important for a futures contract to be successful. It states that private negotiations and non-public spot prices hinder the participation of speculators, because of their lack of information about the “real” spot price. Additionally, it states that government intervention or large transport costs will make a futures contract less attractive. Fortenbery and Zapata (2002) also argues that the lack of an established, public price index was a key reason for the cheddar cheese futures contract not being successful.

[32] There are ways of storing or recycling electricity, but not without quality loss.

The fishmeal market does not, on a general basis, receive much attention from analysts, and can be loosely defined as an "under-analysed" commodity. Also, fishmeal is not publicly traded in an organised marketplace, so there is no public, official price index available to market participants. An industry insider, who prefers to stay anonymous, states that he has tried to establish a price index based on data from fishmeal producers in Chile and Peru, but that he had to close this project because many fishmeal producers refused to collaborate. As long as there is no transparent, trustworthy price index for fishmeal, one cannot say that there is free flow of information in the fishmeal market. This can of course be a classical example of the chicken or egg causality dilemma. It could be that the fishmeal market would receive more analytical attention if a futures market was in place, and that the introduction of a futures contract would bring with it a trustworthy price index.

Fishmeal is traded globally, which implies that it regularly crosses national and trade union borders, and that it is transported over long distances. Peru exports the majority of its production to China (AgroChart, 2017), and this is an excellent example of this dynamic in the fishmeal market. With national and trade union border-crossing and long-distance transport follow potential trade barriers and transportation costs, which is why one cannot say that there is free flow of goods for fishmeal. Our cointegration results show that the South American and Nordic fishmeal markets may be two separate markets, and we hypothesise that such trade barriers and transportation costs may be the reason for this finding. Even though there may not be free flow of goods in the fishmeal market, we believe that this has a negligent effect on the potential success of a futures contract. Almost all commodities, including commodities that have futures contracts, are subject to global trade.

6.2.8 Risk Reduction Through Futures Cross-Hedging

Bekkerman and Tejeda (2017) finds that risk reduction through futures cross-hedging, measured by residual risk, has a negative, insignificant effect on both futures contract existence and trading volume. Brorsen and Fofana (2001) also finds a negative, insignificant relationship between residual risk and futures contract open interest, but a positive, insignificant relationship between residual risk and trading volume. A positive relationship is what should be expected. The negative relationships are therefore somewhat surprising. However, Bekkerman and Tejeda (2017) finds that residual risk has a positive, significant effect on trading volume, if only commodities with futures and support markets are included. Because all mentioned negative relationships are insignificant, the negative relationships are not given any weight in the following discussion. Theory also suggests that the ability to reduce risk through cross-hedging could lead to less demand for an own-hedge futures contract (Black, 1986).

Several studies, including Asche and Tveterås (2004), Gjerde (1989), and Vukina and Anderson (1993), find high hedging efficiencies when cross-hedging fishmeal with soybean meal futures contracts. However, as Figure 11 in Subchapter 2.2 shows, the price ratio of Fishmeal Peru 68% on soybean meal has increased between 2005 and 2017, and it has been very volatile. A reduced linkage between fishmeal prices and soybean meal prices is supported by both Kristofferson and Anderson (2006) and Tveterås (2010), who find evidence of a structural change. Asche et al. (2013) argues that there have been two price regimes, with the change in regimes occurring around 1998.

Franken and Parcell (2011) finds that using corn futures contracts yields a superior hedging-efficiency compared to soybean meal futures contracts when cross-hedging fishmeal. Therefore, in this thesis, both soybean meal and corn futures contracts, separately, are used to estimate residual risk measures[33]. Our findings show only a marginal residual risk difference between the two contracts, where the corn contract produces the lowest one. Hence, the corn measures are used in the estimation of the probability of fishmeal futures contract existence.

However, the residual risk measures for the corn futures contract, presented in Table 7 and Table 8 in Subchapter 5.3, show that this contract does not provide an efficient cross-hedge. The average residual risk between 2005 and 2017 is 0.97, meaning that only 3% of price risk on average could be hedged away using the corn futures contract. This is surprising, given that Franken and Parcell (2011) finds a coefficient of determination of 0.46 when using the corn futures contract, i.e. a residual risk of 0.54. It further finds a coefficient of determination of 0.10 when applying a soybean meal contract. A possible explanation to its findings of low residual risk for the corn contract is that prices of US origin fishmeal could be more correlated with corn prices than those of Peruvian origin fishmeal.

Franken and Parcell (2011) finds that the price series used are stationary, which is also surprising, considering that non-stationarity is found for all years in our price series for other

[33] The calculated coefficients of determination are reported in Table A6 in Appendix A.

fishmeals. Regressing non-stationary price series leads to spurious results with inflated coefficients of determination. If Franken and Parcell's (2011) price series in reality are non-stationary, its presented hedging-efficiency will be inflated. Franken and Parcell (2011) does, however, use data between 1999 and 2007, where average prices are USD 656.27 and USD 633.51 per tonne[34] in Chicago and Minneapolis, respectively. The standard deviations equal USD 198.45 and USD 189.80 per tonne, respectively. For Fishmeal Peru 68% between 2005 and 2017, prices have ranged between USD 615 to around USD 2400 per tonne, trending upwards. In other words, when comparing descriptive statistics of Franken and Parcell's (2011) data with those of our data, assuming the price series were similar before 2005, it appears that the fishmeal price level has shifted upwards. It might be the case that fishmeal prices were stationary before the 2005-2017 period. However, while Franken and Parcell (2011) finds a drastically lower residual risk suggesting that fishmeal prices could indeed be hedged using other contracts, which thereby reduces the need of an own-hedge contract for fishmeal, our results show that such opportunities do no longer exist.

In the calculation of residual risk, cointegration is also tested for. The results, presented in Table A5 in Appendix A[35], show that no cointegration appears to exist between fishmeal prices and corn or soybean meal futures contracts between 2005 and 2017. The lack of a long-run equilibrium relationship does not speak in favour of using corn or soybean meal futures contracts for cross-hedging fishmeal.

While low residual risk might lead to the use of a cross-hedging contract instead of an own-hedge contract, the relevance of this factor when judging the potential success of a futures contract might be reduced if players in the industry do not cross-hedge today. According to an industry insider, cross-hedging is not commonplace in the industry (Sherling, 2018). This helps validate our findings of high residual risk, but it might also be a consequence of either low risk aversion or a lack of knowledge about cross-hedging in the industry.

In summary, based on our findings of high residual risk, all else equal, cross-hedging alternatives do not reduce the need for a futures contract for fishmeal. On the contrary, we

[34] Prices and standard deviations are converted from the per ton, i.e. short ton, measures presented in Franken and Parcell (2011).

[35] There are a few ambiguous results some years. Table A5 in Appendix A highlights these ambiguous results in the notes.

believe that the lack of efficient cross-hedging alternatives speaks in great favour of a fishmeal futures contract.

6.2.9 Liquidity Cost of the Futures Cross-Hedge

The results from Bekkerman and Tejeda (2017) indicate that the volume of the most efficient cross-hedge futures contract, which acts as a proxy for liquidity cost, has a negative, significant effect on futures contract existence. In fact, their results indicate that it is the third most important predictive factor. The same variable is found to have a positive, but insignificant, effect on trading volume. Brorsen and Fofana (2001) does, however, find that the liquidity cost has a negative, and significant, impact on trading volume and open interest. The significant results of Bekkerman and Tejeda (2017) and Brorsen and Fofana (2001) with respect to liquidity cost are in line with the literature on futures contract success. Black (1986), for example, states that hedgers are not only concerned with risk reduction, but with the cost of hedging as well. There is a trade-off between the benefit of an own efficient hedge and the cost of achieving that. For many hedgers, it might be acceptable to cross-hedge, with the lower risk reduction this entails, as long as the cost of this is comparatively low.

Corn and soybean meal futures contracts, which as explained in Section 4.4.1 have been identified as the most efficient cross-hedges for fishmeal, have well-established and large markets for their associated futures contracts. According to data extracted from the Bloomberg Terminal, average weekly trading volume of corn and soybean meal futures contracts on the Chicago Board of Trade in 2017 was 679 946 and 146 391 contracts, respectively. This translates to approximately 86.4 million tonnes of corn and 13.3 million tonnes of soybean meal, per week. The corn and soybean meal futures markets dwarf the fishmeal market with its annual production of approximately 5 million tonnes, which implies that the liquidity cost of a futures cross-hedge should be very low for fishmeal. This speaks against the viability of a fishmeal futures contract. We do, however, believe that the low liquidity cost should be seen in light of the risk reduction the cross-hedge offers. Our findings indicate that both corn and soybean meal futures contracts, on average, offer a risk reduction of approximately 3%. In other words, for all practical matters, there do not exist any viable alternatives for risk reduction among existing futures contracts. Without any cross-hedging alternatives, a trade-off between a relatively expensive, but efficient, own-hedge and a relatively cheap, but inefficient, cross-hedge cannot exist. Following this reasoning, we believe that the liquidity cost of cross-hedging is not a relevant factor when evaluating the potential for a fishmeal futures contract.

6.3 The Exchange and Its Users

Tashjian and Weissman (1995) finds that a futures contract is more attractive to an exchange if it attracts very risk averse participants. The degree to which the participants in the fishmeal market are risk averse is uncertain and greatly subject to speculation in this thesis. We do, however, believe that the considerable uncertainty in future production and prices has the potential to greatly and negatively affect profitability and impose financial distress on fishmeal market participants. This belief is supported by two prominent examples in the fishmeal industry. Exalmar, a large Peruvian fishmeal producer, was by Q4 2016 in breach with the incurrence covenant of its USD 200 million international bond. The incurrence covenant was set at 3.5x Total Debt/LTM EBITDA, while the metric was at 13.1x at the time (Pesquera Exalmar S.A.A., 2017). China Fishery Group, also a large producer of fishmeal, which bought Peruvian fishmeal producer Copeinca for USD 800 million in 2013, has incurred massive amounts of debt that it cannot service, and is currently in Chapter 11 (Sender, 2018). We are of the belief that such examples at least have some effect on increasing risk aversion in the industry, and that it would be in the interest of many participants, especially highly levered producers, to have a risk management tool such as a futures contract available. Additionally, it is likely that lenders will offer more favourable terms if profitability is more stable and possible to forecast, which is something a futures contract could offer.

In its review of the failed futures contract on white shrimp, Sanders and Manfredo (2002) highlights collaboration between the exchange and the users of the contract, i.e. industry players, and education of potential traders as important for futures contract success. With regard to a potential fishmeal futures contract, it is important to clarify the needs and the support of industry players, and for the exchange not to take for granted that industry players understand futures contracts and how they can use them for risk management. Both points are believed to be very important for a potential fishmeal futures contract, seeing that it is not certain what the aggregate needs and interests are in the industry, and because futures contracts are not used for risk management today.

Gray (1966) concludes that two elements are particularly important for a futures contract to be successful. The first element is that firms must want to use the contract for hedging. This aspect has already been discussed, and we believe that the foundations for there being sufficient demand are there. The second element is that speculators must be attracted to the market. Speculators can be thought to be "suppliers of liquidity", and their participation can secure competitive pricing of the contract. In relation to a potential fishmeal futures contract, it is important that the exchange also markets the contract towards speculators such as investors, banks, hedge funds and other groups that may have a speculative interest. It could be argued that, since there are not many listed fishmeal companies, there may be interest in a fishmeal futures contract from speculators who want exposure to an industry that is generally difficult to get exposure to without outright owning a whole private company. It could also be argued that a fishmeal futures contract may have a high correlation with occurrences of the El Niño weather phenomenon, and that this may attract interest from, for instance, insurance companies and hedge funds.

Tashjian and Weissman (1995) mentions that two cases of differences between short and long participants, i.e. fishmeal producers and feed producers and/or speculators, can have influence on the success of a futures contract. In the first case there are hedgers on one side of the contract and speculators on the other. If hedgers have specialised positions subject to high price risk, while speculators have less specialised positions (e.g. does not prefer one maturity date over another), this type of difference may stimulate speculative demand. This is because hedgers may be willing to give considerable price concessions to speculators. The second case has a similar effect and can occur if short and long participants have the same hedging demand, while there are differences in risk aversion between the two groups. Tashjian (1995) exemplifies this effect with a short farmer that is more risk averse than a long processor, where the processor may be willing to make larger trades as long as it is offered price concessions from the farmer (which he will be willing to offer due to his relatively larger risk aversion). Conditions in the fishmeal market may facilitate both of these effects. First, fishmeal producers do indeed have specialised positions, and these positions are subject to considerable price risk. Speculators have less specialised positions, in that they may have a more flexible demand and/or timing profile. Therefore, it is reasonable to assume that fishmeal producers may be willing to give price concessions, and thus drive speculative demand. Second, both fishmeal producers and feed producers are subject to price risk, and both should therefore have high hedging demand, ceteris paribus. Fishmeal producers' revenue and cost bases are, however, generally less diversified than those of feed producers, and fishmeal producers may thus be relatively more risk averse. Because of this, fishmeal producers may be willing to give price concessions to feed producers, and thus drive larger trading volume.

Bekkerman and Tejeda (2017) finds that the presence of successful futures contracts in support markets, i.e. markets of jointly produced and marketed commodities, has a positive effect on the success of an agricultural commodity futures contract. While not satisfying the definition of a support market, it may be that such an effect can be present for commodities within the same value chain as fishmeal. Should such an effect be present, it may be that the already existing salmon futures contract electronically traded on Fishpool in Bergen, Norway can have a positive effect on the trading volume of a potential fishmeal futures contract. We believe that this is not an unreasonable assumption, because a fishmeal futures contact can offer a, hitherto unavailable, risk management tool for hedging the fishmeal portion of salmon farming companies' cost bases. Soybean meal, wheat and other important feed ingredients already have futures contracts, and thus a large portion of the feed cost base could, if a futures contract for fishmeal existed, be hedged.

Salmon farming companies, among others, would be potential buyers of a fishmeal futures contract. Because Fishpool already offers salmon futures contracts, the exchange could be a natural place to list a potential fishmeal contract, seeing that it already has members that have interest in the contract and because these members have been educated about the utility and use of futures contracts. We believe that the geographical spread of the fishmeal market, that must be noted does not have a natural centre in Norway, could weaken trading in the contract, but that this can be countered with the fact that Fishpool is an electronic marketplace and with heavy marketing. Another suggestion would be to dual or triple list the contract on exchanges in the Peru/Chile area, the Nordic area and/or China and thus have more local presence in global fishmeal centres. A dual or triple listing must, however, technically function as one listing, because separate listings of contracts will reduce liquidity, and thus reduce hedging efficiency.

6.4 Optimal Design of a Potential Futures Contract for Fishmeal

Aldinger (1991), Bollman, Garcia and Thompson (2003), Perversi, Feuz and Umberger (2002), Sanders and Manfredo (2002), and Thompson, Garcia and Wildman (1996) all conclude that poor contract design was the main reason for the failure or lack of success of the futures contracts for broiler, diammonium phosphate, stocker cattle, white shrimp, and high fructose corn syrup, respectively. The papers unanimously agree that a poorly designed contract impels lower liquidity and hedging efficiency.

Bergfjord (2007), Black (1986), Gray (1966), Silber (1981), and Tashjian and Weissman (1995) argue that a futures contract's attractiveness to both hedgers and speculators are important to the success of the contract. Both groups' needs should therefore be taken into consideration when designing it. In addition, Bergfjord (2007) and Black (1986) suggest that the contract must balance flexibility in the contract specification and vulnerability to manipulation.

Bergfjord (2007) argues that meeting the speculators' needs is less of a challenge, where they "could simply be asked about their contract preferences" (p. 122). Hedgers' needs are, however, more complex.

In the previous subchapters of Chapter 6, several challenges for a potential fishmeal futures contract have been identified. These challenges are mainly related to homogeneity, activeness of the cash market, vertical integration, buyer concentration, and price transparency. To ensure optimal design of a futures contract for fishmeal, we want to maximise the hedging efficiency given the traits of fishmeal and its market discussed in the previous subchapters, and at the same time make the contract attractive to speculators and mitigate the risk of manipulation.

Important aspects of contract design are settlement form, construction of the underlying index, and other contract provisions such as contract size, maturity months and position limits.

6.4.1 Settlement Form

The settlement form of the contract can be either cash or physical. According to Lien and Tse (2003), cash settlement appears to be the best solution for heterogeneous commodities with high delivery costs. In addition, Bergfjord (2007) states that cash settlement removes the problem of trade restrictions. Due to some uncertainty related to homogeneity and because delivery costs can be high, cash settlement seems to be the optimal choice.

However, cash settlement might affect the convergence of spot and futures prices towards maturity of the futures contract, as the direct link between the spot and the futures price is removed (Bergfjord, 2007). Although this could reduce the hedging efficiency, i.e. increase the basis risk, not demanding fishmeal to be physically delivered should encourage a broader set of participants to take part in the market, such as speculators. Tashjian (1995) argues that liquidity in the futures contract is particularly important in the case of uncertain supply at the time the contract is made, or if a speculator with a short trading horizon is one of the parties to the contract. The former case is highly relevant to the fishmeal market, and hence it seems crucial to ensure satisfying liquidity early on. While the flexibility necessary for attracting speculators might reduce hedging efficiency, there are still no competing contracts that potential hedgers could replace a fishmeal futures contract with. Hence, reduced hedging efficiency could be bearable for hedgers.

6.4.2 The Underlying Index

The goal when constructing the underlying index should be to maximise futures contract liquidity and hedging efficiency, while mitigating the risk of index manipulation.

The first problem in relation to the underlying index is the lack of price transparency and assurance in the industry. Fishmeal is not publicly traded on an exchange, and manipulation can therefore occur in the form of price-reporting agents, who might have positions in the futures market, providing biased reports (Lien & Tse, 2003). In the construction of the underlying index, this risk could be mitigated by collecting several prices, preferably from independent and objective bodies. Due to the importance of the fishmeal industry in some countries, objectiveness could be assured by having a private organisation outside the industry collect prices, as opposed to governmental organisations that might have conflicting interests. The second, and perhaps even more important, problem in the fishmeal industry is related to the risk of manipulation through market power. A large part of the production is concentrated in few geographical areas, where some producers have large market shares. Consequently, some producers, particularly Peruvian companies which produce the fishmeal acknowledged as the price leader in the industry, may have the incentive and ability to manipulate futures prices. Specifically, this might be done by consciously manipulating spot prices and incurring losses in this market to gain on positions in the futures market. The risk of manipulation makes it crucial that the underlying index is quality-assured.

Powers (1967) states that close correspondence between contract provisions and trade practices is important in attracting hedging. Pirrong, Haddock and Kormendi, referenced in Powers (1967), supports this by arguing that common centralised delivery areas should be reflected in contracts' explicit delivery locations, for buyers and sellers to be attracted into the market. In the matter of fishmeal, a basket of different qualities from different locations, with delivery in the largest fishmeal production country, Peru, could be a reasonable solution. To the extent it is possible, fishmeal prices from different locations could then be adjusted for transportation costs. This is in line with the current practice for salmon futures contracts traded on the Fishpool exchange.

If Fishpool introduces the contract, as proposed in Subchapter 6.3**,** delivery in Peru could be argued to help attract potential participants not located in the Nordic market. Using a basket of different qualities and prices takes into account the high degree of buyer concentration in the market. While not eliminating the risk of manipulation, such a construction helps mitigate it. A composite index will thus be positive in terms of attractiveness to speculators.

Our findings indicate that there is a lack of market cointegration between South America and the Nordics, and incorporating prices from both areas into one index might reduce overall hedging efficiency. The two geographic markets will probably not be large enough to sustain two separate futures contracts, and if they were, liquidity would likely be low, which would also reduce hedging efficiency.

To further prevent manipulation by large participants, there should be an Asian-style settlement, in which the settlement price equals the average price in a predetermined time period, for example a month. However, this will also, as other efforts to counter manipulation, reduce hedging efficiency.

6.4.3 Contract Size, Maturity Months and Position Limits

Following Powers (1967), the contract size and trading months chosen should reflect the characteristics of the fishmeal market. When improving the failed broiler contract, these contract provisions were among those changed to ensure better correspondence with actual market trades (Aldinger, 1991).

A standard shipping container holds 20-25 tonnes of fishmeal (Sherling, 2018). A contract size of 25 tonnes should therefore be highly relevant, in line with commercial practice, and will not exclude any hedgers from the market. However, it is worth noting that speculators might prefer smaller contract sizes. The MidAmerica Commodity Exchange replicated prices from other markets, but reduced the size of each contract (Black, 1986; Silber, 1981). This led to more speculators being attracted, and illustrates how important such modifications can be to contract success.

In terms of maturity months, the picture is slightly more complicated. Pirrong, Haddock and Kormendi, referenced in Powers (1967), states that maturity months normally reflect trade and production practice. Peru has two Anchoveta catch seasons[36]: one winter season and one summer season. The winter season is usually set to last from November to January, while the summer season is usually set to May through June (Sherling, 2018). In the Nordic region, the largest catches of pelagics that are reduced to fishmeal are typically seen in the two first quarters of the year (Sherling, 2018). Listing of contracts with maturity in January, February, March, April, May, June, November and December could then be a reasonable suggestion that reflects trade and production schedules. It could also be reasonable to include a July contract to provide a hedge for any remaining production and trading, and because the Peruvian summer season may be extended.

Silber (1981) mentions position limits as a component of a futures contract's design that can affect the desirability to hedgers or speculators. For a potential fishmeal futures contract, position limits might help hinder manipulation. While trading volume might be reduced, placing restrictions on the size of participant's trades, either as a share of total volume of the contract or as a maximum number of contracts held, a wider range of potential participants might be attracted to the market. Such an arrangement could be reasonable for a limited time period after the contract is launched, until the trading volume and number of participants are sufficiently high to mitigate the risk of manipulation not handled by other contract provisions.

6.5 Discussion Summarised

This chapter has discussed many aspects, and an overview of the most important points and findings of Subchapters 6.1-6.4 is warranted.

First, in Subchapter 6.1, the results from applying fishmeal to Bekkerman and Tejeda's (2017) model were discussed. The model perfectly predicts the true case of fishmeal not having a futures contract, but the discussion uncovered that it might not be ideal for an assessment of

[36] The catch seasons are regulated by the Peruvian government.

whether a new contract is viable, and that some of the estimated effects break with widely accepted theory. Second, we also pointed to that the model overlooks the effect market value has on the probability of futures contract existence. Because of these problems, one cannot conclude that a futures contract for fishmeal is not viable based on these results alone.

Second, in Subchapter 6.2, characteristics of the fishmeal market and other futures contracts, that are relevant for the success of futures contracts, were discussed. With respect to fishmeal as a commodity, the discussion uncovered that there is considerable uncertainty, that evidence point toward fishmeal, at least separately in the South American and Nordic regions, and possibly altogether, is homogenous, that the size of the cash market is adequate to sustain a futures contract, and that fishmeal is storable. All these factors are positively related to futures contract success. On the other hand, the discussion also uncovered the existence of vertical integration and buyer concentration, low cash market activeness and low transparency in the fishmeal industry, which is negative for a potential futures contract. With respect to other futures contracts, the discussion uncovered that there are no efficient futures contracts available that make cross-hedging fishmeal worthwhile, and that the possible liquidity cost of a futures cross-hedge thus is irrelevant. These points are positive for a potential futures contract.

Third, in Subchapter 6.3, the exchange to offer a potential fishmeal futures contract and the users of the contract were discussed. The discussion uncovered that fishmeal industry players at least have reasons to be risk averse, that the foundations for attracting speculators are there, and that the existence of the salmon futures contract might attract demand from hedgers already familiar with futures contracts. All these factors speak in favour of the viability of a fishmeal futures contract. Additionally, we pointed to that it is important that the exchange collaborates with potential users, and that it must take on an educative role to attract demand. We also proposed that the electronic futures exchange Fishpool, based in Bergen, Norway, may be a viable alternative for the listing of a potential fishmeal futures contract, or that the contract may be dual or triple listed in Peru/Chile, Norway, and/or China.

Finally, in Subchapter 6.4, optimal design of a potential fishmeal futures contract was discussed. Based on findings in this thesis and the discussion throughout this chapter, we propose that a potential fishmeal futures contract may be cash settled, that the underlying price index should be an Asian-style index based on a basket of different quality grades and locations with delivery in Peru, that the contract size should be set to 25 tonnes, and that maturity months may be set to November-July. Additionally, it could be reasonable to enforce position limits until the trading volume and number of market participants are sufficiently large to mitigate manipulation risk.

7. Conclusion

The objective of this thesis is to clarify whether a potential fishmeal futures contract is viable. With success factors for futures contracts identified by the literature in mind, we have conducted two separate quantitative analyses, and the results from these were applied in a following qualitative analysis of all success factors. First, a cointegration analysis was conducted to clarify fishmeal's homogeneity and market size. This indicated that there exists a long-term equilibrium relationship between prices of different fishmeals within the Nordic and South American submarkets, separately, but not across them. Second, as a proxy for futures contract success, Bekkerman and Tejeda's (2017) model was applied to predict the probability of a fishmeal futures contract already existing. Results from a Delphi survey of industry experts on fishmeal constituted some of the measures of the variables used in the model. The results from applying Bekkerman and Tejeda's (2017) model on fishmeal unambiguously, and correctly, concluded that there is a zero percent probability of fishmeal futures contract existence between 2005 and 2017. Our analysis may have stopped here, but this question deserves a more nuanced analysis than a binary conclusion.

Our qualitative analysis has uncovered that there are many factors speaking in favour of the viability of a fishmeal futures contract. First, there is considerable uncertainty tied to future fishmeal prices, which especially has its roots in the uncertainty of the El Niño weather phenomenon. Shifts in prices have the potential to materially affect the finances of industry players and can potentially lead to bankruptcy. This uncertainty should lay foundation for some degree of risk aversion in the fishmeal industry, and thus bring demand for a futures contract. Second, fishmeal has been assessed to be sufficiently homogenous for a futures contract to be relevant for a broad part of the industry. Third, the fishmeal production has been deemed to be large enough to sustain a contract, especially when factoring in that the per tonne price of fishmeal is high compared to many other commodities. Fourth, fishmeal has been assessed to be a storable good. Fifth, the trade-off between a cheap, but less efficient cross-hedge futures contract and a relatively expensive, but efficient own-hedge futures contract has been assessed not to be relevant. There are currently no existing futures contracts that provide an acceptable hedging efficiency for fishmeal. Finally, our assessment of potential users, both hedgers and speculators, and the existence of a salmon futures contract, also point toward the viability of a fishmeal futures contract.

However, there are also factors speaking against the viability of a fishmeal futures contract. First, our analysis revealed that there is a high degree of both vertical integration and buyer concentration in the fishmeal industry. The existence of vertical integration is both a problem for launching a contract and a symptom of the non-existence of a contract. The lack of a standardised and market-based risk management tool has increased the benefit of vertical integration, and perhaps been a driving force for this tendency in the fishmeal and aquaculture industries. Ceteris paribus, the emergence of vertical integration has reduced both the need and demand for a futures contract for those in the industry that are integrated, and the existence of it therefore speaks in disfavour of the viability of a contract. The existence of buyer concentration implies that a futures contract could be exposed to manipulative forces, and that the market for it would have few potential participants. The risk of manipulation is an important problem, and any futures contract subject to it will have difficulties with attracting trading. Second, our analysis revealed that there is low cash market activeness and transparency in the fishmeal market. There are no public, organised auctions in which fishmeal is traded, and there is generally a lack of quality-assured, transparent real-time information flows of prices, volumes, demand and supply. It has also been revealed that some industry players have discouraged efforts to increase transparency. This speaks greatly in disfavour of the viability of a fishmeal futures contract, because transparency and "a level playing field" with respect to information generally are prerequisites for any efficient, functional financial market.

Optimal contract design can somewhat mitigate the inherent problems of buyer concentration and risk of manipulation. Feeding several prices of different qualities from different locations into a composite, Asian-style settlement index will greatly reduce the opportunity for prices to be manipulated by any one participant in the fishmeal market. The establishment of such an index requires that large fishmeal market participants are willing to collaborate. This has not been the case in the past, but should the willingness to collaborate have changed since then, and the infrastructure to collect these prices be funded, buyer concentration and risk of manipulation will be less of a problem. Contract design cannot, however, mitigate the problem of vertical integration, and the establishment of a futures contract will almost certainly not lead to any untangling of integration in the industry. This is because fishmeal producers and aquaculture companies still benefit from securing access to raw material with vertical integration.

The factors speaking in favour of a fishmeal futures contract being viable highlight the benefits such a contract could have. The factors speaking in disfavour, however, highlight that there are characteristics of the market that pose serious threats to the viability of a fishmeal futures contract. In particular, the existence of market power and vertical integration makes the establishment of a fishmeal futures contract difficult. Should it, however, be established, it seems unlikely that it could sustain a successful market over time. Therefore, our conclusion is that a fishmeal futures contract, under current market conditions, is not viable.

8. Limitations, Weaknesses and Suggestions For Future Research

This chapter will address limitations and weaknesses of the analyses in this thesis, and propose suggestions for future research.

8.1 Limitations and Weaknesses

First, utilising the Delphi method to determine measures for homogeneity, activeness of the cash market, buyer concentration, and vertical integration for fishmeal has some inherent weaknesses, as highlighted by Brorsen and Fofana (2001). The opinions of our survey panel may diverge from reality, and might thus not be representable. In this thesis, it has been pointed to that some respondents might have biased opinions because of their affiliation to, and point-of-view from, companies that want to market fishmeal as a premium product rather than a commodity. Additionally, all respondents were aware that fishmeal does not already have a futures contract, and this may have influenced their responses. The fact that only seven experts completed both rounds of the survey may also have made our results sensitive to extreme responses. We do, however, believe that the pool of respondents was balanced, and that Chapter 6 provides a more nuanced and critical discussion of the possibly biased responses.

Second, we have not formally tested for the law of one price (LOP) between different fishmeal prices, but rather used our cointegration results as an indication of whether fishmeal is homogenous or not. A formal test of the LOP would have yielded more precise answers. We did, however, find it to lie outside the scope of this thesis, and that the method utilised gave sufficient answers for our purposes.

Third, the focus of this thesis has been on fishmeal of South American and Nordic origin. Ideally, had the data been available to us, we should have also included Asia, and China in particular. Data on fishmeal of Asian origin has, however, been very difficult to obtain. Because South American and Nordic origin fishmeal, measured by production size, constitute a large part of the market, we still believe that our results are representable.

Fourth, our utilisation of Bekkerman and Tejeda's (2017) model to predict whether a fishmeal futures contract is viable also has its weaknesses, as addressed in Subchapter 6.1. The model was developed to predict the probability of current existence of a futures contract for a given agricultural commodity. Applying it to a potential fishmeal futures contract may thus not be an ideal way of determining the viability of it. Additionally, the model estimates residual risk and volatility to have a negative effect on the probability of existence of a futures contract, which contradicts theory on contract success. Despite the weaknesses of this model, the results from applying it to fishmeal are consistent with the reality of there not existing a fishmeal futures contract today and are in line with our final conclusion.

Finally, as addressed in Section 6.2.1, comparing the coefficient of variation of fishmeal with those of commodities with existing futures contracts is not an ideal method. Comparing volatility across time periods is also not ideal. Alternative ways of determining whether the price volatility of fishmeal is sufficient are, however, not without its flaws. We believe that the method utilised, when combined with the more nuanced discussion in Section 6.2.1, provides a representable picture of the price uncertainty in the fishmeal market.

8.2 Suggestions for Future Research

We have unearthed two interesting topics suitable for future research while writing and researching for this thesis.

First, considering that we have not found a potential fishmeal futures contract to be viable, we suggest researching the viability of an El Niño weather phenomenon derivative. In theory, all measurable events can be written derivatives on, but to our knowledge, a standardised El Niño derivative does not exist. In our research, we stumbled upon the Oceanic Niño Index (ONI) published by National Oceanic and Atmospheric Administration (NOAA). The index is based on sea surface temperature departures from the normal, and is used for monitoring, assessing and predicting occurrences of the El Niño and La Niña weather phenomena (National Oceanic and Atmospheric Administration, 2018). This index might be a suitable, transparent settlement index. Our hypothesis is that El Niño related derivatives could attract demand from, among other, the fisheries industry and the fishmeal industry, as well as the agricultural industry, electric power industry, insurers and speculators such as hedge funds.

Second, we also suggest researching the price relationships between different origins and quality gradings of fishmeal. The cointegration test results in our thesis indicate that price series of fishmeal of Nordic and South American origin, irrespective of quality gradings, are cointegrated within submarkets, but not across submarkets. The fact that we have not found indications of cointegration relationships across submarkets imply that there are no long-run equilibrium relationships between prices of fishmeal from the Nordics and South America, i.e. that there are two independent fishmeal markets. A further investigation into this finding, factoring in frictions, should be of great interest to the fishmeal industry.

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Appendix A

Table A1: Detailed Overview of FOB and CFR Incoterms

Incoterm	FOB	CFR
Export customs declaration	Seller	Seller
Carriage to port of export	Seller	Seller
Unloading of truck in port of export	Seller	Seller
Loading on vessel/airplane in port of export	Seller	Seller
Carriage (sea/air) to port of import	Buyer	Seller
Insurance	Buyer	Buyer
Unloading in port of import	Buyer	Buyer/Seller
Loading on truck in port of import	Buyer	Buyer
Carriage to place of destination	Buyer	Buyer
Import customs clearance	Buyer	Buyer
Import duties and taxes	Buyer	Buyer

Source: Wikipedia (2018)

Table A2: Descriptive Statistics of Price Series of Fishmeal, and Soybean Meal and Corn Futures

Price series in USD/mt	Obs.	Mean	Std. dev.	Min	Max
Fishmeal Peru 68%	682	1417.50	411.09	615.00	2400.00
Fishmeal Peru 67%	682	1391.20	404.80	610.00	2380.00
Fishmeal Peru 64%	682	1238.83	348.44	550.00	2240.00
Fishmeal Chile 68%	394	1697.11	270.39	1290.00	2400.00
Fishmeal Iceland 71%	421	1723.31	199.45	1210.00	2220.00
Fishmeal Denmark 72%	421	1745.80	192.57	1263.00	2190.00
Soybean meal futures	682	351.43	96.53	165.90	600.43
Corn futures	682	170.39	60.89	73.32	327.25

Table A3: Overview of Respondents in Delphi Survey on Fishmeal

Name	Position	Company or institution	Country
Sigbjørn Tveterås	Professor	University of Stavanger	Norway
Frank Asche	Professor	University of Stavanger and Duke University	United States/ Norway
Jon Tarlebø	Chief Executive Officer	Norsildmel AS	Norway
Hans de Wit	Regional Director Americas	Köster Marine Protein GmbH	Peru/Germany
Geir Småvik	Purchasing Director Fishfeed	Marine Harvest ASA	Norway
José Rainuzzo	Research and Development Manager	Tecnológica Alimentos S.A. (TASA)	Peru
Niels Alsted	Vice President Asia	Biomar Group A/S	China/Denmark

Section A1: Delphi Survey on Fishmeal

In the Delphi survey on fishmeal, the respondents presented in Table A3 in Appendix A were asked to respond to the four questions that follow, over two rounds. In the first round, the questions were phrased exactly as they are presented in this section. In the second round, respondents were also presented with standard deviations, medians, averages, and a one standard deviation range. The questions are loosely adapted to fit fishmeal and were originally phrased in Brorsen and Fofana (2001).

Question 1: Homogeneity (Grading Effectiveness)

Consider the effectiveness of the grading system for fishmeal. A grading system is effective if a commodity is homogenous or if grades adequately explain differences in value.

A scale of 1-10 is used to rate the degree of homogeneity. A ranking of 10 should indicate that fishmeal is very homogenous, and a ranking of 1 should indicate that fishmeal is not homogenous.

Please circle the number (only one) you think best describes the degree of homogeneity of fishmeal below. In your response, please consider only the time period from January 1, 2005 through February 28, 2018.

Question 2: Activeness of the Cash Market

Consider the activeness of the cash market for fishmeal. The activeness of a market is determined by the percentage of market participants quoting bids and offers, and the frequency with which they are quoted. An active cash market is one in which market participants quote bids and offers daily. A less active cash market is one in which fewer participants quote bids and offers, or bids and offers are quoted less frequently.

A scale of 1-10 is used to rate the activeness of the fishmeal cash market. A ranking of 10 should indicate that fishmeal has a very active cash market, and a ranking of 1 should indicate that fishmeal does not have an active cash market.

Please circle the number (only one) you think best describes the degree of activeness in the cash market for fishmeal below. In your response below, please consider only the time period from January 1, 2005 through February 28, 2018.

Question 3: Vertical Integration

Consider the degree of vertical integration across one or several pricing points for fishmeal. Vertical integration includes both ownership and contract integration. The degree of vertical integration depends on the number of pricing points and the percentage of the commodity priced at each point. Consider only pricing points where the form is not changed. Some commodities (live cattle, for example) have only one pricing point where form is not changed (from feedlot to packer), whereas others (wheat, corn, etc.) have multiple pricing points where their form is not changed. The more pricing points without form being changed, then the lower should be the measure of vertical integration.

A scale of 1-10 is used to rate the degree of vertical integration in the fishmeal market. A ranking of 10 should indicate that the fishmeal market has a very high degree of vertical integration, and a ranking of 1 should indicate that the fishmeal market is not vertically integrated.

Please circle the number (only one) you think best describes the degree of vertical integration in the market for fishmeal below. In your response below, please consider only the time period from January 1, 2005 through February 28, 2018.

Question 4: Buyer Concentration

Consider concentration of firms at the pricing points for fishmeal. Some commodities (live cattle, for example) have a single pricing point, whereas others (wheat, corn, etc.) have multiple pricing points. Concentration is defined as the percentage of a commodity handled by the largest firms. For commodities with a single pricing point, consider only buyer concentration. For commodities with multiple pricing points, concentration should indicate an average concentration across all buyers.

A scale of 1-10 is used to rate the degree of concentration of the market for fishmeal. A ranking of 10 should indicate that fishmeal has a very concentrated market (i.e., a small number of firms at all the pricing points), and a ranking of 1 should indicate that fishmeal does not have a concentrated market (i.e., a large number of firms at all the pricing points).

Please circle the number (only one) you think best describes the degree of buyer concentration in the market for fishmeal below. In your response below, please consider only the time period from January 1, 2005 through February 28, 2018.

Table A4: ADF test for Stationarity

Year	Fishmeal		Soybean meal futures		Corn futures	
	Constant	Constant & trend	Constant	Constant & trend	Constant	Constant & trend
2005	0.837 (1)	-2.655 (1)	-1.478 (1)	-1.450 (1)	-2.074 (3)	-1.782 (1)
Δ2005	-6.926** (0)	-7.171** (0)	-7.867** (0)	-7.775** (0)	-2.018 (8)[a]	-1.826 (8)[a]
2006	-2.026 (1)	-1.317 (1)	-1.450 (1)	-1.460 (1)	0.161 (3)	-1.124 (3)
Δ2006	-2.549 (2)[a]	-2.797 (2)[a]	-7.650** (0)	-7.683** (0)	-3.433** (2)	-3.626* (2)
2007	-1.259 (3)	-1.983 (3)	-0.019 (1)	-1.368 (1)	-1.501 (0)	-1.179 (0)
Δ2007	-2.732 (2)[a]	-2.719 (2)[b]	-3.600** (2)	-3.915* (2)	-2.349 (4)[a]	-2.975 (6)[a]
2008	-0.650 (1)	-2.038 (1)	-1.305 (7)	-1.616 (7)	-0.903 (1)	-1.853 (1)
Δ2008	-4.237** (0)	-4.930** (0)	-2.424 (6)[a]	-2.193 (6)[a]	-1.925 (7)[a]	-2.354 (7)[a]
2009	1.094 (1)	-1.703 (2)	-1.817 (1)	-1.766 (1)	-2.414 (0)	-1.433 (1)
Δ2009	-4.251** (0)	-4.644** (0)	-3.783** (3)	-3.796* (3)	-5.124** (1)	-5.134** (1)
2010	-1.463 (1)	-1.738 (1)	-0.776 (0)	-4.051* (0)	0.783 (1)	-1.962 (1)
Δ2010	-3.508* (0)	-3.393 (0)[a]	-4.510** (2)	-4.897** (2)	-3.727** (2)	-4.128* (2)
2011	-2.638 (5)	-4.457** (5)	-1.433 (1)	-2.845 (1)	-1.400 (4)	-2.343 (4)
Δ2011	-3.328* (4)	-3.431 (4)[a]	-3.691** (5)	-3.762* (5)	-2.994* (6)	-3.598* (6)
2012	-0.218 (1)	-1.997 (1)	-1.886 (1)	-0.408 (1)	-1.547 (1)	-1.676 (7)
Δ2012	-5.343** (0)	-5.322** (0)	-4.086** (1)	-4.731** (1)	-6.111** (0)	-2.613 (6)[a]
2013	-1.592 (9)	-2.714 (9)	-3.246* (3)[c]	-3.244* (3)[c]	-0.461 (1)	-2.526 (3)
Δ2013	-1.778 (8)[a]	-1.753 (8)[a]	-2.967* (6)	-2.928 (6)[a]	-2.849 (6)[a]	-2.806 (6)[a]
2014	-0.800 (2)	-3.198 (2)	-1.665 (1)	-2.663 (1)	-2.766 (8)	-2.725 (8)
Δ2014	-3.087* (1)	-3.057 (1)[a]	-2.015 (10)[a]	-1.920 (10)[a]	-1.192 (7)[a]	-1.131 (7)[b]
2015	-2.198 (3)	-1.352 (2)	-0.836 (1)	-1.514 (1)	-3.198* (7)[c]	-2.544 (8)
Δ2015	-2.653 (2)[a]	-3.068 (2)[a]	-5.790** (1)	-5.870** (1)	-7.643** (0)	-7.553** (0)

2016	-1.948 (1)	-2.374 (1)	-1.352 (1)	-1.178 (1)	-1.985 (4)	-2.143 (4)
Δ2016	-3.093* (6)	-3.225 (6)[a]	-5.116** (0)	-5.107** (0)	-3.072* (6)	-3.027 (6)[a]
2017	-1.944 (2)	-1.951 (1)	-2.541 (2)	-2.296 (2)	-1.520 (6)	-2.800 (1)
Δ2017	-1.962 (8)[a]	-2.633 (8)[a]	-3.419** (3)	-3.529** (3)	-3.224** (3)	-5.245** (2)

Note: Critical values as per MacKinnon (1990, 2010) presented in Stata. Lags are reported in parenthesis.

*** indicates 1% significance level, * indicates 5% significance level.*

[a]: Cannot reject a null hypothesis of stationarity with KPSS test at 5% significance level.

[b]: Can reject a null hypothesis of stationarity with KPSS at 5% significance level.

[c]: Cannot reject a null hypothesis of non-stationarity with DF-GLS at 5% significance level.

Table A5: Engle-Granger Cointegration Test for Fishmeal, Soybean Meal Futures and Corn Futures

Year	Variable 1	Variable 2	Constant	Constant & trend
2005	Fishmeal	Soybean meal futures	0.410 (1)	-2.759 (1)
	Soybean meal futures	Fishmeal	-1.489 (1)	-1.443 (1)
	Fishmeal	Corn futures	0.014 (3)	-2.738 (1)
	Corn futures	Fishmeal futures	-2.159 (3)	-1.810 (1)
2006	Fishmeal	Soybean meal futures	-2.090 (1)	-1.697 (1)
	Soybean meal futures	Fishmeal	-1.495 (1)	-1.681 (1)
	Fishmeal	Corn futures	-1.783 (3)	-2.131 (3)
	Corn futures	Fishmeal	0.081 (3)	-1.838 (3)
2007	Fishmeal	Soybean meal futures	-1.690 (3)	-2.374 (3)
	Soybean meal futures	Fishmeal	-0.695 (3)	-1.676 (3)
	Fishmeal	Corn futures	-0.045 (3)	-2.673 (3)
	Corn futures	Fishmeal	-0.709 (3)	-1.692 (3)
2008	Fishmeal	Soybean meal futures	-1.746 (7)	-1.746 (7)
	Soybean meal futures	Fishmeal	-2.493 (7)	-1.938 (7)
	Fishmeal	Corn futures	-3.299 (1)	-3.299 (1)
	Corn futures	Fishmeal	-3.455 (1)	-3.449 (1)
2009	Fishmeal	Soybean meal futures	0.374 (1)	-2.532 (2)
	Soybean meal futures	Fishmeal	-1.894 (1)	-2.495 (2)
	Fishmeal	Corn futures	0.608 (1)	-1.833 (2)
	Corn futures	Fishmeal	-1.495 (1)	-1.749 (2)
2010	Fishmeal	Soybean meal futures	-2.035 (1)	-1.593 (1)
	Soybean meal futures	Fishmeal	-1.755 (1)	-2.831 (1)
	Fishmeal	Corn futures	-1.548 (1)	-1.754 (1)
	Corn futures	Fishmeal	-0.659 (1)	-1.672 (1)
2011	Fishmeal	Soybean meal futures	-2.377 (5)	-3.803 (5)
	Soybean meal futures	Fishmeal	-1.500 (5)	-1.305 (5)
	Fishmeal	Corn futures	-2.282 (5)	-4.780** (5)[a]
	Corn futures	Fishmeal	-1.186 (5)	-2.020 (5)
2012	Fishmeal	Soybean meal futures	0.150 (1)	-2.104 (1)
	Soybean meal futures	Fishmeal	-0.806 (1)	-0.691 (1)
	Fishmeal	Corn futures	-0.834 (1)	-2.248 (1)
	Corn futures	Fishmeal	-1.748 (1)	-1.942 (7)
2013	Fishmeal	Soybean meal futures	-2.261 (9)	-4.313* (9)[a]
	Soybean meal futures	Fishmeal	-1.784 (9)	-1.752 (9)
	Fishmeal	Corn futures	-2.139 (9)	-2.251 (9)
	Corn futures	Fishmeal	-2.283 (9)	-2.234 (9)
2014	Fishmeal	Soybean meal futures	-2.206 (2)	-2.913 (2)
	Soybean meal futures	Fishmeal	-2.490 (2)	-2.659 (2)
	Fishmeal	Corn futures	-1.923 (8)	-2.681 (8)
	Corn futures	Fishmeal	-3.116 (8)	-3.354 (8)

2015	Fishmeal	Soybean meal futures	-2.026 (3)	-1.554 (2)
	Soybean meal futures	Fishmeal	-1.173 (3)	-1.913 (2)
	Fishmeal	Corn futures	-2.241 (7)	-2.912 (8)
	Corn futures	Fishmeal	-3.148 (7)	-2.419 (8)
2016	Fishmeal	Soybean meal futures	-2.184 (1)	-3.792 (1)
	Soybean meal futures	Fishmeal	-1.710 (1)	-2.897 (1)
	Fishmeal	Corn futures	-1.749 (4)	-2.095 (4)
	Corn futures	Fishmeal	-2.191 (4)	-2.158 (4)
2017	Fishmeal	Soybean meal futures	-2.178 (2)	-2.328 (2)
	Soybean meal futures	Fishmeal	-3.114 (2)	-3.393 (2)
	Fishmeal	Corn futures	-1.812 (6)	-2.296 (1)
	Corn futures	Fishmeal	-1.856 (6)	-3.417 (1)

Note: Critical values as per MacKinnon (1990, 2010) presented in Stata. Lags are reported in parenthesis.

*** indicates 1% significance level, * indicates 5% significance level.*

[a]: Indication of cointegration for one of the bivariate tests.

Table A6: Coefficients of Determination (R^2) from Regressing Fishmeal Price on Future Contract Prices of Soybean meal and Corn

Cross-hedge contract	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Soybean meal futures	0.049	0.000	0.012	0.036	0.002	0.023	0.000
Corn futures	0.007	0.075	0.001	0.032	0.030	0.020	0.005

Cross-hedge contract	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Average**
Soybean meal futures	0.002	0.114	0.037	0.014	0.031	0.000	0.017
Corn futures	0.028	0.008	0.059	0.035	0.020	0.024	0.024

Appendix B

Table B1: Engle-Granger Test for Cointegration for Fishmeal Price Series

Variable 1	Variable 2	Constant	Constant & trend
FM Peru 68%	FM Peru 64%	-3.788* (5)	-4.227* (5)
FM Peru 68%	FM Peru 67%	-3.848* (3)	-5.401** (3)
FM Peru 68%	FM Chile 68%	-7.293** (4)	-7.484** (4)
FM Peru 68%	FM Iceland 71%	-2.860 (6)	-3.432 (6)
FM Peru 68%	FM Denmark 72%	-2.733 (6)	-3.659 (6)
FM Peru 64%	FM Peru 68%	-3.884* (5)	-4.214* (5)
FM Peru 64%	FM Peru 67%	-4.124** (5)	-4.358** (5)
FM Peru 64%	FM Chile 68%	-4.595** (5)	-4.854** (5)
FM Peru 64%	FM Iceland 71%	-3.325 (6)	-3.467 (6)
FM Peru 64%	FM Denmark 72%	-3.200 (6)	-3.643 (6)
FM Peru 67%	FM Peru 68%	-3.849* (3)	-5.375** (3)
FM Peru 67%	FM Peru 64%	-4.039** (5)	-4.334* (5)
FM Peru 67%	FM Chile 68%	-6.546** (4)	-6.538** (4)
FM Peru 67%	FM Iceland 71%	-2.937 (6)	-3.388 (6)
FM Peru 67%	FM Denmark 72%	-2.838 (6)	-3.627 (6)
FM Chile 68%	FM Peru 68%	-6.908** (4)	-6.978** (4)
FM Chile 68%	FM Peru 64%	-4.706** (5)	-4.993** (5)
FM Chile 68%	FM Peru 67%	-6.791** (4)	-6.755** (4)
FM Chile 68%	FM Iceland 71%	-3.004 (6)	-3.533 (6)
FM Chile 68%	FM Denmark 72%	-2.776 (6)	-3.614 (6)
FM Iceland 71%	FM Peru 68%	-3.117 (6)	-3.606 (6)
FM Iceland 71%	FM Peru 64%	-3.345 (6)	-3.559 (6)
FM Iceland 71%	FM Peru 67%	-3.172 (6)	-3.582 (6)
FM Iceland 71%	FM Chile 68%	-3.058 (6)	-3.535 (6)
FM Iceland 71%	FM Denmark 72%	-3.650* (6)	-5.462** (6)
FM Denmark 72%	FM Peru 68%	-2.973 (6)	-3.900* (6)
FM Denmark 72%	FM Peru 64%	-3.167 (6)	-3.786 (6)
FM Denmark 72%	FM Peru 67%	-3.046 (6)	-3.884* (6)
FM Denmark 72%	FM Chile 68%	-2.763 (6)	-3.618 (6)
FM Denmark 72%	FM Iceland 71%	-3.570* (6)	-5.484** (6)

*Note: Critical values as per MacKinnon (1990, 2010) presented in Stata. "FM" refers to Fishmeal. Lags are reported in parenthesis. ** indicates 1% significance level, * indicates 5% significance level.*

Table B2: Norsildmel's Specifications of Super Prime, Prime and Standard Fishmeal

Contents	Super Prime		Prime		Standard	
	Max	**Min**	**Max**	**Min**	**Max**	**Typical**
Protein		68.00 %		67.00 %		67.00 %
Moisture	10.00 %		10.00 %		10.00 %	
Fat (Soxhlet)	11.50 %		11.50 %		11.50 %	
Salt (NaCl)	4.00 %		4.00 %		4.00 %	
Salmonella	Not detected		Not detected		Not detected	
Antioxidant	Ethoxyquin		Ethoxyquin		Ethoxyquin	
Contaminants	EU limits		EU limits		EU limits	
Histamine	500 ppm		1000 ppm		n/a	

Source: Norsildmel (2018a), *Norsildmel* (2018b), *and Norsildmel* (2018c)

Table B3: Hayduk Corporación's Specifications of Super Prime, Prime and Standard Fishmeal

Contents	Super Prime		Prime		Standard	
	Max	**Min**	**Max**	**Min**	**Max**	**Min**
Protein		68.00 %		67.00 %		64-65%
Fat	10.00 %		10.00 %		10.00 %	
Moisture	10.00 %		10.00 %		10 %	
FFA	7.50 %		10.00 %		n/a	
Ashes w/o salt	14.00 %		15.00 %		n/a	
Sand & salt	4.00 %		4.50 %		5.00 %	
TVN	100 (100mg/100gr)		120 (100mg/100gr)		n/a	
Histamine	500 ppm		1000 ppm		n/a	
Antioxidant		150 ppm		150 ppm		150 ppm

Source: (Hayduk Corporación, 2018)

Table B4: Pesquera Exalmar's Specifications of Super Prime, Prime and Standard Fishmeal

Contents	Super Prime		Prime		Standard	
	Max	**Min**	**Max**	**Min**	**Max**	**Min**
Protein		68-70%		67.00 %		64-67%
Fat		10.00 %		10.00 %		10.00 %
Moisture	10.00 %		10.00 %		10.00 %	
Salt and sand	4.00 %		5.00 %		5.00 %	
Sand alone	1.00 %		2.00 %		2.00 %	
TVN	100 mg/gr		120 mg/gr		n/a	
Histamine	500 ppm		1000 ppm		n/a	
Antioxidants		150 ppm		150 ppm		150 ppm
FFA	7.50 %		10.00 %		n/a	

Source: Pesquera Exalmar (2018)

Table B5: Copeinca's Specifications of Super Prime, Prime and Standard Fishmeal

Contents	**Super Prime**		**Prime**		**Standard**	
	Max	**Min**	**Max**	**Min**	**Max**	**Min**
Protein		68.00 %		67.00 %		65.00 %
Fat	10.00 %		10.00 %		10.00 %	
Moisture	10.00 %		10.00 %		10.00 %	
Sand	1.00 %		1.00 %		1.00 %	
Salt and sand	4.00 %		5.00 %		5.00 %	
FFA	7.50 %		10.00 %		n/a	
TVN	100 mg/100g		120 mg/100g		n/a	
Histamine	500 ppm		500 ppm		n/a	
Antioxidant	150 ppm		150 ppm		150 ppm	

Source: Copeinca (2018)