Essays on International Trade of Salmon and Wine

by

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Summary

This thesis deals with the trade of two products, salmon and wine, exported from and to Norway. The World has benefitted from innovations and productivity growth in the Norwegian salmon aquaculture industry, increasing the availability of salmon worldwide at more affordable prices. In the same way, Norway has benefitted from the global surge in wine production stemming from competition between 'new' and 'old' wine-producing countries, resulting in more affordable and higher quality wines. Thus, export of a commodity, such as salmon, allows welfare-enhancing imports of another, such as wine. This trade encapsulates the workings of a small open economy like Norway's.

The topics covered in this thesis deal specifically with *trade relationships*. First, it deals with trade relationships between the Norwegian salmon exports, trout exports and the destination markets. Second, it deals with relationships between wine exporters in different wine-producing countries and wine importers in Norway. In particular, we focus on market links, through the *interaction between prices* in different levels of the international value chain, and links between agents, through the *interaction between exporting firms and importing firms*. The analyses of these relationships involve different methodological approaches, including descriptive statistics, regression, cointegration analysis and duration analysis.

The results from the analyses show strong links between Norwegian export prices of salmon and the retail prices in key markets like France and UK. Moreover, the export prices tend to lead the retail prices, so the supply is key to understand changes in prices facing the final consumers. However, it also shows that price transmission from export prices diminishes with processing, as salmon increasingly is just one of several inputs in the final retail product. The findings also show that Atlantic

salmon is the price leader of rainbow trout, with the export prices of the two species tightly integrated.

In terms of agents in trade, the salmon exports show that larger firms appear to obtain no price bonuses in the export markets. This observation corresponds to earlier research showing larger exporters sell a larger share on contracts and long-term agreements. Many smaller exporters operate in the spot markets resulting in many single trades, that nevertheless can be surprisingly large in value. In the wine imports, we find that the duration of importer-exporter trade relationships decreases when an increasing number of importers compete for wine from a wine-producing country. However, the more valuable the wine becomes, the more importers and exporters seem to invest to maintain their trading partnership.

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1 Introduction

This PhD thesis deals with international trade and investigates different aspects of trade relationships in a small open economy, Norway. Gaining more insights about trade is highly relevant particularly for small open economies, as growth in trade of goods and services is one of the key drivers of globalization and economic growth. The welfare in these economies are highly dependent on how they explore their comparative advantages.

Figure 1 shows that the value of global trade as share of World GDP has increased from below 40% during the 1980s to around 60% during the 2000s. For a small open economy like the Norwegian, which is the main source of trade data used for the analyses in this thesis, trade's relevance is obvious. Through the period shown in Figure 1, trade as share of Norway's GDP has ranged between 60 and 80%. As a small economy, Norway is a large exporter of a few groups of goods, particularly oil and petroleum services, metals and minerals and seafood where the country have a clear resource advantages in a Heckscher-Olin sense, providing the income that allows the imports of the varied set of goods and services that are expected by the consumers in developed countries.

As Hummels (2007) discusses, an important driver of trade growth has been technological advances reducing transportation costs. However, to better understand trade dynamics and relations underlying the graph in Figure 1, a richer set of variables and models must be employed. In this thesis, the trade data we analyze focus on two distinct markets, salmon and wine. In the global salmon market Norway is the world's largest exporter, and salmon aquaculture is also important as a recently developed industry. In the global wine market, on the other hand, Norway is a small importer with hardly any production on its own. More specifically, this thesis analyses certain traits of trade using different methodological approaches, with a focus on price relationships, aspects of product differentiation and the duration of trade relationships,

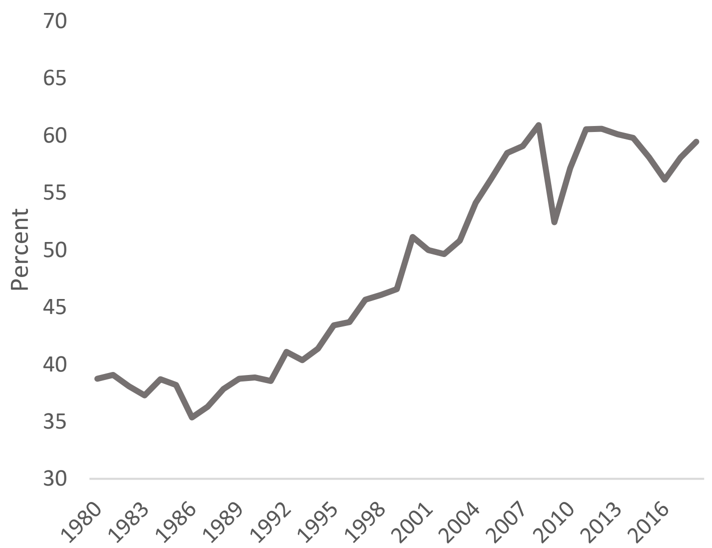

Figure 1. Trade as share of World GDP, 1980-2018 (World Bank).

Since international trade consists of numerous exporters, importers and goods shipped over state borders, a key to describe and analyze trade activity is through their constituent *relationships*. Aggregate trade data mask the complexity and dynamics of the underlying trade relationships (Besedeš and Prusa 2006a). This is because the data often report total volume and value for a good or group of goods on monthly, quarterly or annual basis. However, as more recent studies show, behind those aggregate figures are much more dynamics taking place and more complex relationships than the relative stability of the aggregate trade data signals (Besedeš and Prusa 2011).

For example, the typical duration of a trade relationship between an individual exporting firm and importing firm is much shorter than the trade duration one finds at the country-to-country level (Straume 2017). In a similar manner, average prices of a traded commodity can also mask important differences in prices, which will appear when a product is disaggregated in its various product formats and in different parts of the value chain. A relevant question with traded prices is also whether they are driven by the supply side (i.e., the exporter) or by the demand side (e.g., at the retail level in the importer market). Increased access to microdata or simply more disaggregated data than the conventional country-to-country trade data can accordingly provide new insights into how trade works. Moreover, more detailed data can give shed light on distinct research questions as exemplified by the papers contained in this study.

Two of the papers focus on trade relationships, which can be interpreted as the pairwise links created between an importer and an exporter. Traditionally, most studies of trade relationships have been on the country level (Besedeš and Prusa 2006a). In this thesis, we have the benefit of having access to transaction level data that gives the opportunity to analyze firm-to-firm relationships. In one study, we analyze the duration of trade relationship in the imports of wine to Norway using survival analysis. In another study, we use the transaction data to describe the trade relationships and links that shapes salmon exports from Norway. Both studies provide new insights on how trade is conducted in these two markets.

The two remaining papers of the thesis focus on price relationships. The first study analyzes price transmission of fresh salmon exported from Norway to the final products in retail chains in France and UK. This study has the benefit of consumer panel data from France and UK that allow calculation of prices for a range of retail products where Norwegian fresh salmon is the main input. This disaggregation of price data on type retailed salmon products allow a better understanding of the links between export price and the final retail price.

The final study in thesis analyzes horizontal price linkages between two different salmonid species exported from Norway, Atlantic salmon and rainbow trout. The Atlantic salmon has come to dominate the salmon market through exceptional growth, while the growth of rainbow trout has stagnated, but nonetheless its supply prevails. This leads to some interesting questions about the place of rainbow trout in the bigger scheme of things. These two price analyses mean that both horizontal and vertical price linkages related to the exports of salmon are analyzed.

In sum, these case studies further document complexities associated with trade linkages in international markets and provide new insights. For a trade-reliant economy like the Norwegian, it is important to understand decision variables and dependencies on counterparts for the individual agents and price determinants for its exported products.

2 Background

The next section gives an overview of the Norwegian trade with these salmon and wine. This is relevant to understand the particularities of the markets and trade flows and how the findings in this thesis can be transferable to other settings. Since three of the studies in the thesis deals with the Norwegian exports of salmon and only one with Norwegian imports of wine, the salmon market is described in more detail.

2.1 Trade case: Salmon exports

International trade in salmon is very much a product of globalization, where innovations in aquaculture technology enabled farmed fish to be competitive and win market share (Anderson, Asche, and Garlock 2018). First, the industry benefitted by innovations related to production technology that allowed it to reduce production cost and made it profitable to increase production despite reducing the price (Asche 2008).

Secondly, the industry has benefitted from the innovations in logistics and transportation, which has facilitated increased air and land transportation of both fresh and frozen salmon (Asche, Roll, and Tveteras 2007; Kvaløy and Tveterås 2008; Asche, Cojocaru, and Roth 2018). Salmon trade has also benefitted from the global spread of international food retail chains (Reardon et al. 2003; Reardon and Timmer 2012). The pink-fleshed fish has provided just the type of perishable food product that retail chains thrive on – large and predictable supply and with a consistent quality. These characteristics have allowed retail chains to optimize logistics, develop new products and plan marketing campaigns around (Anderson, Asche, and Tveterås 2010).

Hence, the precondition for the trade growth is the huge productivity growth in salmon farming. The productivity growth has been thoroughly documented in several studies (Asche, Guttormsen, and Tveterås 1999; Sun, Kumbhakar, and Tveterås 2015; Asche, Guttormsen, and Nielsen 2013; Roll 2019).

Since the growth in farmed salmon production has taken place in few countries, it is also few countries that dominate exports. Norway is the largest salmon producer globally and exports most of its output. Figure 2 shows monthly exports of fresh salmon from Norway and the average price associated with those exports. The export volume kept growing until around 2013, after which growth stagnated. While these trends show a certain continuity in the total trade flows, they mask the dynamics of the individual trades and trade relationships that is the aggregate flow is made up of.

With the telling title "Here today, gone tomorrow", Straume (2017) showed that trade relationship between Norwegian salmon exporters and importing countries are relatively fickle. In the data sample analyzed in that study, the duration of the exporter-firm-to-importer-country relationship is on average four years. That is, on average, trading partners maintain a trading relationship for four years before it ends. This implies that the exporter-firm-to-importer-firm relationship should be even shorter, since the degree of disaggregation is even finer.

Straume (2017) also showed that variables that form part of gravity models, such as distance, income and exchange rates, also affect duration of trade relationships. Moreover, in markets where many Norwegian exporting firms are active, the average duration appears to be lower. This indicates that exporters compete more strongly for keeping trade relationships in lucrative or large volume markets.

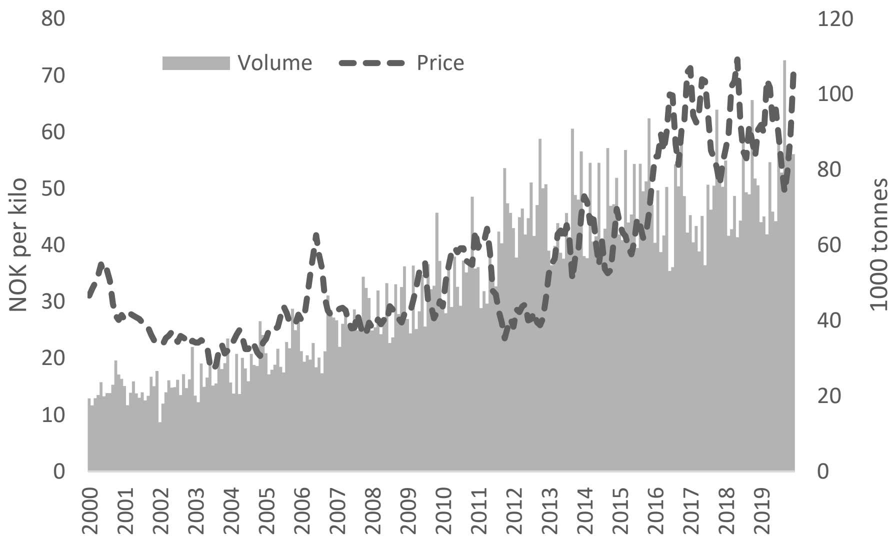

Figure 2. Monthly exports and price of salmon from Norway (Statistics Norway).

Knowledge about market structure can help us understand how trade dynamics change over time. For example, for seafood markets it has been argued that since the waves of food retail chains that rolled-out during the 1980s, 1990s and 2000s to cover most urban areas on the planet has led to a huge shift in retailing of fish (Anderson, Asche, and Tveterås 2010; Berg Andersen et al. 2009). In many countries, the traditional fish monger has completely disappeared and been replaced by seafood counters in supermarkets. As a result of salmon buyers becoming bigger, a larger share of salmon trades is done on contracts and long-term agreements (Larsen and Asche 2011). This affects both trade dynamics and prices. In particular, price volatility decreased with growing the share of trades on long-term contracts (Dahl and Oglend 2014).

The increasing concentration in the retailing of salmon has also inspired research on buyer power in international trade of salmon (Asche et al. 2011; Fofana and Jaffry 2008; Guillotreau, Grel, and Simioni 2005). However, the increasing concentration has not only taken place on the buyer side. The salmon industry itself has become more concentrated through a process of a partial deregulation of the industry in Norway and subsequent consolidation (Asche et al. 2013).

Figure 1 also shows that in the period that growth has stagnated, prices have soared. Several recent studies have addressed the increase in salmon prices and linked to both to factors that restricts output like disease outbreaks and salmon lice, to demand growth, and to increases in input prices like feed (Abolofia, Asche, and Wilen 2017; Asche and Oglend 2016; Asche, Oglend, and Selland Kleppe 2017; Asche, Misund, and Oglend 2019; Brækkan et al. 2018). The research questions in this thesis is not about the underlying factors driving this surge in salmon prices but rather how such a price trends influences other prices in international salmon markets, vertically and horizontally.

Many studies have investigated price relationships in salmon and trout markets. Studies stretching back to the early 1990s and onwards analyzed market integration (DeVoretz and Salvanes 1993; Asche, Steen, and Salvanes 1997; Asche and Sebulonsen 1998; Asche, Bremnes, and Wessells 1999; Tveteras and Asche 2008; Nielsen et al. 2007). These studies analyze the extent of international salmon markets both geographically, across country borders, and qualitatively, across different types of salmon species and products. A couple of studies also analyze market integration between salmon and other species (Berg Andersen et al. 2009; Nielsen, Smit, and Guillen 2009).

Studies of price transmission in the salmon market appeared around a decade later than the first market integration studies. For example, Asche, Jaffry, and Hartmann (2007) analyzed to what degree export prices of fresh salmon transmitted to wholesale and retail prices of smoked salmon. Asche et al. (2014) analyze if structural changes in the value chain has affected price transmission in France. An earlier study by Guillotreau, Grel, and Simioni (2005) also studied how structural changes in the French salmon market affected vertical price transmission. Simioni et al. (2013) also analyze price transmission in the French supply chain using a threshold model to investigate hypotheses linked to market power. Another development that can be linked to the previous mentioned shift in retailing of seafood from fishmongers to supermarkets is an increased variety of consumer products based on salmon (Asche et al. 2014).

Product differentiation

Atlantic salmon has its own market for forward contracts, which reflects its status as a commodity.[1] The categorization of salmon as a commodity is supported by the research on market integration discussed above support. These studies have found strong integration of prices across products and regional markets. However, its status as a commodity does not mean that is strictly a competitive market or that it strictly homogenous product. As Sexton (2013) discusses, few agricultural (or, for that sake, aquaculture) markets qualify as purely competitive markets.

The reason for this is twofold. First, very few agricultural products are of the exact same quality. They differ in sensory characteristics, size and in terms of product presentation. Secondly, the increasing consolidation along food chains go against the assumption of competitive markets with many buyers and sellers. Both of these considerations are relevant for the salmon market. As we have discussed, in the salmon market there have both been an increasing concentration on the buyer side (retail chains) and on the seller side, i.e., the salmon industry.

Product differentiation is another factor that can influence market structure of salmon trade (and which role is explored in this thesis). For example, besides Atlantic salmon there are other species in the salmon market such as rainbow trout, char, sockeye, and coho. Even if the species forming part of the salmon market have common traits like pink

[1] http://fishpool.eu/

flesh, the exact color varies among species type and what they have been fed, with colors ranging from whitish to deep red (Alfnes et al. 2006; Forsberg and Guttormsen 2006). Other attributes that distinguish them and that can influence consumer buying decisions are size, fat content, flavor, smell, consistency and texture of the meat. As a result, even in a product as commodified as salmon, product differentiation can take place in many dimensions. This leads us over to the next trade case covered in this thesis, wine imports to Norway. Compared to salmon, product differentiation, as we will argue, plays a much larger role for wines.

2.2 Trade case: Wine imports

Just like the markets for salmon are globalized, so is the case for wine. The globalization of wine markets has accelerated during the last decades driven by entry of new producers and economic growth boosting demand (Balogh and Jámbor 2017). Especially, the increased supply from New World producers such as Australia, Chile, New Zealand, South Africa, USA and many other smaller producer countries have increased supply (Mariani, Pomarici, and Boatto 2012). Moreover, the economic growth in China has been the main engine in a significant demand growth in Asian markets (Anderson and Wittwer 2013; Cardebat and Jiao 2018).

The trade growth has upended trade patterns as traditional wine producers in France, Germany, Italy and Spain have met increased competition from new producers in their core markets and shifted to consumers in new markets who recently acquired taste for their fine wines (Anderson and Wittwer 2013). The globalization has also made many producers in the traditional producing countries that only served the domestic market to invest additionally, enabling them to export and penetrate international markets. On the other hand, many new-world producers have early on targeted international markets as domestic markets were small.

In this globalized wine market of shifting trading patterns, Norway with its 5.5 million inhabitants is a small wine importer, but being an affluent market still makes it for an interesting case study. Moreover, the parallel with salmon is obvious in that where Norway is a new producer utilizing a market opportunity in the seafood market for salmon, Norway as a wine importer benefits from the increased supply and competition in the wine market. As figure 2 shows, the imports from Norway increased from 2004 to 2014, which is the data period covered in this thesis.

A characteristic that distinguishes wine from salmon is a much larger degree of product differentiation. The product differentiation is both along the horizontal and vertical axis; for example, depending on the mix of grapes, terroir and production process the same priced wine can lead to distinct taste, smell and color that will appeal to different consumers. Also, there are similar kinds of wine produced on the same grapes, but that varies greatly in reputation and quality (e.g., as reflected in the complexities of smell and taste), resulting widely different price levels (Oczkowski and Doucouliagos 2014). This makes it of interest to analyze how quality differences affect trade patterns. For example, Crozet, Head, and Mayer (2011) show that higher quality wines, or champagnes more specifically, are more likely to be exported. Thus, for a wine producer the probability to export increases with the quality of its wines. However, product differentiation can have further implications for wine trade. Besedeš and Prusa (2006b) show that increasing degree of product differentiation lead to longer duration of trade relationships. This can also have implications for imports of wine, and is one of the questions investigated in this thesis.

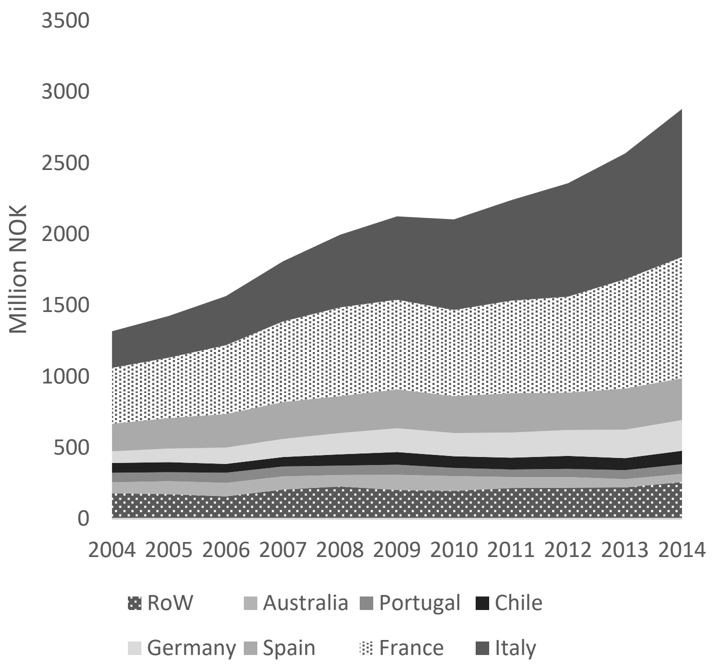

Figure 3. Wine imports to Norway by producing country (Statistics Norway).

3 Summary of papers

3.1 Farmed fish to supermarket: Testing for price leadership and price transmission in the salmon supply chain

Co-authored with Frank Asche, Daniel V. Gordon & Sigbjørn L. Tveteraas

Published in Aquaculture Economics & Management, 22:1, 131-149, DOI: 10.1080/13657305.2017.1284943

We measure the extent of price transmission from Norwegian export price to retail prices of salmon in France and UK. The data represent monthly observations (2005–2014). Of the original 17 retail products examined only 8 cointegrate with export prices. Of these, all but one reject a null of full price transmission and all show price causality from export to retail level. The results show that price transmission decreases to retail prices as more processing is involved and for packaged salmon products compared to salmon sold in the fresh fish counter.

Most natural fresh products such as fillets and steaks do show a high degree of price transmission from Norwegian export prices to retail prices. These products account for almost a third of retail sales by value in France and almost half of sales in the United Kingdom. The added-value products ready-prepared main meals in France and fresh breaded in the United Kingdom show a very low value of price transmission.

Nonetheless, in all products testing cointegrated with export prices, price leadership from export prices to retail prices is measured.

The relationship between the magnitude of marketing costs and price transmission does not appear to be straightforward; e.g., for a product with a high markup like fresh smoked salmon the price transmission from fresh salmon raw material remains significant. This seems to be linked to relatively few inputs involved where it is the cost of the salmon raw material that creates the largest variation in the overall costs of the final product.

3.2 Salmon trout? The forgotten cousin

Co-authored with Atle Oglend

This study investigates potential economic reasons why production of trout is maintained in Norway by analyzing prices and production for Norwegian Atlantic salmon and trout. The results show that the markets for fresh and frozen rainbow trout are tightly integrated with fresh Atlantic salmon, and, where the latter is a price leader. This means that many consumers consider the two products as substitutes, with no clear preferences. Most farmers appear to prefer Atlantic salmon. However, the economic disadvantage with producing salmon trout does not appear to be large, given that the production level is maintained even in this environment.

With no clear economic reasons for why farmers are producing salmon trout, it is likely to maintain a precarious position. Production was going down in the late 1980s until the Japanese preference for red-fleshed salmon opened that market. That is a pattern that may well be repeated if one cannot find new market segments with a clear preference for salmon trout. This is a risk that may be exacerbated by new production technologies in salmon aquaculture such as land-based farming (Bjørndal and Tusvik, 2019), which does not seem to be applied to production of salmon trout. On the other hand, disease risk appears to be an increasingly important factor in salmon production. Oglend and Tveteras (2009) argue that geographical diversification is a potential tool. Moreover, there may exist a fringe of consumers that prefer its characteristics, motivating firms to maintain its production as a means of diversification.

3.3 *Insights from transaction data: Norwegian aquaculture exports*

Coauthored with Hans-Martin Straume & Atle Oglend

This paper discusses how transaction data can be used to shed light on trade dynamics in seafood exports, with Norwegian salmon exports as the case. Our findings reveal that a few exporters take a disproportional large part of total exports, meaning that a few "superstars" dominate exports. We also find that larger sized export markets attract a larger number of salmon exporters. These findings are in line with most of the literature on exports at the firm level. However, the data also reveals several interesting differences from the common findings in the literature. First, most exporters sell to many buyers and in many different markets, instead relying on a few trading-partner relationships. One interpretation of this is that, despite a large share of salmon being sold on contracts and long-term relationships (Larsen and Asche 2011), there is still a considerable share that is sold spot, that is, sold indiscriminately to whoever pays the market price. This is also supported by the finding that large share of export value traded in *one-off trade relations* is remarkably high.

Second, the largest exporters do not receive any significant price premium. This again can be linked to that the largest exporters rely more on contracts than the smaller exporters. As a result, lower price volatility associated with contracts comes at a price, specifically, a lower average price. Growth in salmon exports is found to be driven largely by the intensive margin, reflecting an industry in a consolidation process. In the literature of international trade the common insight is that trade volume primarily grows along the extensive margin of trade. A reason why our findings differ in this respect may be due to differences in the level of aggregation – that we are looking at one industry and have firm-to-firm data in the trade relationship.

3.4 Buy the good wine: Duration of Norwegian wine imports

Coauthored with Frank Asche and Hans-Martin Straume

Global wine trade continues to grow with new agents entering the market (Balogh & Jámbor, 2017). In this paper, we employ transaction level data to analyse the duration of trade relationships in wine imports to Norway from 2004 to 2014. We find that most relationships are short-lived, as more than 75% of trade relationships end after less than two years. The main focus of this study is how trade duration is influenced by wine quality as reflected by the price (Oczkowski & Doucouliagos, 2014). Wine is a highly differentiated product with a large spectrum of different qualities and tastes. We show that imports of higher priced wines is associated with longer duration of trade relationships. As expected a weakening of the exporters currency contributed to lengthen the duration of trade relationships.

Another important result is that there is an asymmetric effect of the number of importers from the number of exporters. While an increase in the number of importers appears to increase competition to the detriment of duration trade relations, an increase in the number of exporters appear to have the opposite effect. This result may arise because for most wine exporters Norway is just one of several markets where they can export their product. Norwegian importers, on the other hand, compete both for a limited number of wines known to sell well in Norway and for access to a limited shelf-space in the Wine monopoly's retail stores. In contrast, the presence of more exporters from the same wine-producing country may induce incumbent exporters to hold onto their trade relations more dearly – increasing trade duration.

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List of papers

Ursula Landazuri-Tveteraas, Frank Asche, Daniel V. Gordon & Sigbjørn L. Tveteraas (2018) Farmed fish to supermarket: Testing for price leadership and price transmission in the salmon supply chain, *Aquaculture Economics & Management*, 22:1, 131-149, DOI: 10.1080/13657305.2017.1284943

FARMED FISH TO SUPERMARKET: TESTING FOR PRICE LEADERSHIP AND PRICE TRANSMISSION IN THE SALMON SUPPLY CHAIN

Ursula Landazuri-Tveteraas[1], Frank Asche[1,2], Daniel V. Gordon[1,3] and Sigbjørn L. Tveteraas[1]

☐ *In this paper, we measure the extent of price transmission and test price leadership in the salmon supply chain. The data represent monthly observations (2005-2014) on export price of fresh salmon from Norway and on retail prices for a variety of salmon products in France and U.K. The contribution is to use a Johansen bivariate time-series approach to quantify the degree of price transmission on a broader set of consumer salmon products than has been previously studied. Of the original 17 retail products examined only 8 cointegrate with export prices. Of these, all but one reject a null of full price transmission and all show price causality from export to retail level. Price transmission to retail prices decreases, as more processing is involved and increases for packaged salmon products compared to salmon sold in the fresh fish counter.*

Keywords: salmon supply chain, price leadership, export and retail prices

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Introduction

Salmon is a versatile product. It is cooked, grilled, steamed, grinded, sliced and cut and thereafter reassembled with new textures and flavours; be it with soya sauce and wasabi for sushi or mixed with spices as canned paté spread. Salmon is also available as high end product as organic, sushi grade and smoked. On retail shelves salmon can be found as expensive branded or as affordable private label products. The diversity of products has opened the market to consumers with wide-ranging incomes, tastes and preferences, and increased demand for salmon (Asche et al, 2011; Brækkan and Tyholdt, 2014).[1]

With the diversity of salmon products, we observe a wide range of consumer prices. These prices reflect the cost of farmed fish plus the share of processing costs, marketing costs, and the specific demand characteristics of the customer segment targeted. Processing salmon into value-added consumer products involves additional inputs of labour and capital including packaging, branding and marketing. It is likely that the greater the share of these non-raw material costs the less the price influence of the farmed fish on the final product price. On the other hand, where farmed fish is the important input in the final consumer product (e.g., fresh salmon fillets and steaks) one would expect a strong price relationship in the supply chain (Singh, 2016; Asche et al., 2014; Asche, Jaffry & Hartmann, 2007).[2] The many factors involved in setting retail price may lead to incomplete price transmission and the question remains as to the degree of price transmission in the salmon supply chain.

Other factors are also important in setting retail price including storage (Heien, 1980; Wohlgenant, 1985), menu costs (Heien, 1980), market power (Asche et al., 2011; Fofana & Jaffry, 2008; Guillotreau et al., 2005), and sales arrangements i.e., contracts vs. spot sales (Kvaløy and Tveteras, 2008; Olson and Criddel, 2008; Asche et al., 2013; 2014; Larsen & Asche, 2011). We do not measure for these factors but the importance may have increased in fish price determination with the rise of supermarkets as purveyors of final fish products[3].

These factors may also contribute to incomplete price transmission. Perhaps an even more important characteristic of the salmon market is the extent of price leadership in the supply chain. The interest here is in measuring whether price shocks at the retail level lead and push through the supply chain, and the possibility of feedback effects.

The purpose of this paper is to measure price relationships in the salmon supply chain from export to retail market. For this study, data available for empirical study represent monthly prices for the period January 2005 to December 2014 on exports of fresh salmon from Norway and on retail prices for a variety of processed and semi-processed salmon products in France and U.K.[4] The price data available for retail products is limited to those products with complete time series observations over the period of analysis. Our empirical strategy is to apply time series techniques to measure price transmission in the salmon supply chain. The Johansen procedure (Johansen, 1988; 1991) is ideally suited for our purposes and allows testing for cointegration i.e., an equilibrium relationship among the variables. If cointegration is observed, we can measure the extent of price transmission and test for complete price transmission and price leadership. We use a bivariate time-series approach to measure the price relationship between Norwegian salmon export price and specific retail prices in France and U.K. and to test for price transmission and leadership in the markets examined.

Studies of upstream production have linked the long-term reduction of salmon prices to productivity improvements (Andersen, Roll & Tveteras, 2008; Asche, Roll & Tveteras, 2007; Roll, 2013; Asche, Roll & Tveteras, 2016; Asche and Sikveland, 2016). Cheaper salmon has been a key incentive for market growth and the development of new consumer products based on salmon. The subsequent market growth also explains why price relationships have received so much attention in empirical studies of salmon markets (Asche, et al., 2011; Asche et al., 2014; Asche, Jaffry & Hartmann, 2007; Guillotreau et al., 2005;

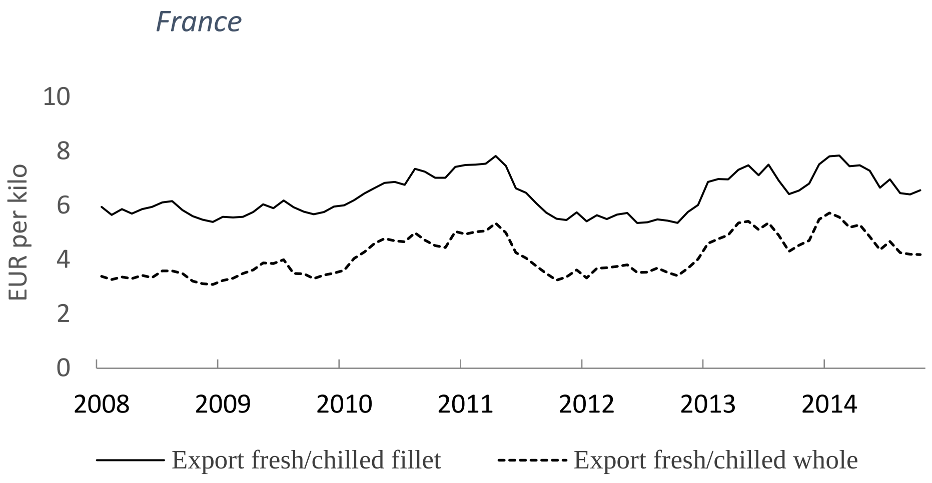
Simioni et al., 2013; Tveteras & Asche, 2008). These studies have investigated different nodes in the supply chain and found various degrees of transmission from upstream to downstream prices. Interestingly, more recent studies suggest that in the salmon market price transmission from producer to consumer prices has decreased because of structural changes in fish processing and retailing (Asche et al., 2014; Guillotreau et al., 2005; Simioni et al., 2013). With the rise of supermarkets in dominating retail fish market sales, an increasing share of salmon is bought on contracts (Larsen & Asche, 2011) and sold on private label (Guillotreau et al., 2005; Bronnmann and Asche, 2016).

The paper is organized as follows; the next section presents a summary discussion of the data used in estimation. Next, the basic price transmission model is described within a Johansen framework. Following this, empirical results are reported. The final section provides summary comments.

Data

The data available for empirical work are provided by the Norwegian Seafood Council and EuroPanel[5] and represent monthly export price of fresh salmon from Norway and retail prices of certain processed or semi-processed products in France and U.K. Based on availability, the complete data set for France covers the period monthly 2008-2014 and for U.K. monthly 2005-2014. Export price are unit values derived as the ratio of monthly value to quantity. Monthly household consumer surveys[6] collected in both France and UK are used to define average monthly retail prices.

Figure 1 shows monthly Norwegian export prices[7] for fresh fillet and fresh whole salmon to France and U.K. for the defined periods. For France, prices for both products follow a similar trend with a slight increase in price in early 2011 and again in 2013 but otherwise we observe stable prices over the period. Notice that the margin between the two products is basically constant over the period. For this time period, fresh salmon fillet average 6.38 €/kg and fresh whole average 4.15 €/kg[8]. For U.K., export prices show a positive trend with somewhat greater variation in margin over the period. For this time period, fresh salmon fillet average 6.17 €/kg and fresh whole average 3.95 €/kg[9].



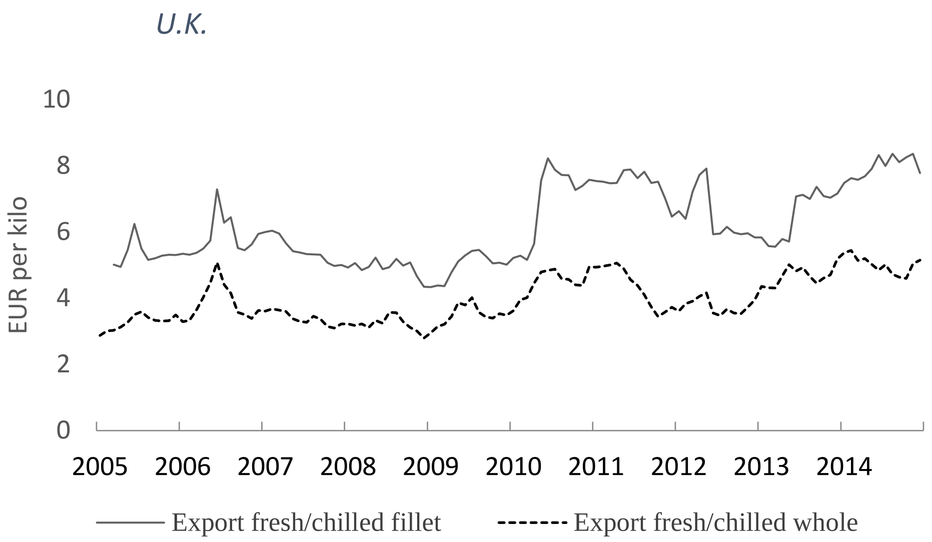
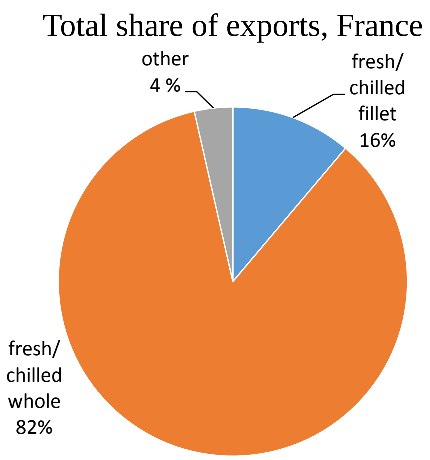


Figure 1. Norwegian export prices monthly France and U.K., fresh fillet and fresh whole salmon (source: Norwegian Seafood Council)

Figure 2 shows that the vast majority of volume share of Norwegian export to both France and U.K. is fresh whole product; some 82% of total exports for France and the corresponding number for U.K. is 85%. Figure 2 makes clear that in terms of export volume to both France and U.K. minimal processing is involved. This is explained by the Norwegian cost of labour and increased European import taxes on processed products.



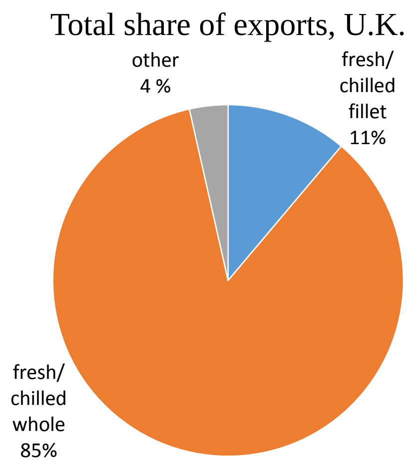
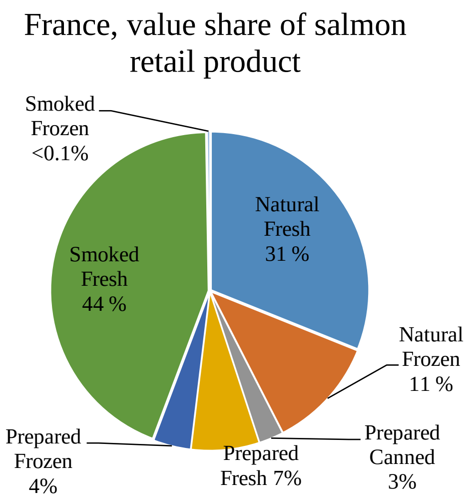


Figure 2. Norwegian salmon export shares to France and U.K., 2013
(source: Norwegian Seafood Council)

Figure 3 shows for 2013 value shares at the retail level of processed and semi-processed salmon product for both France and U.K. Notice the differences in the two countries in taste preferences with the largest retail share as smoked fresh in France and natural fresh in U.K.



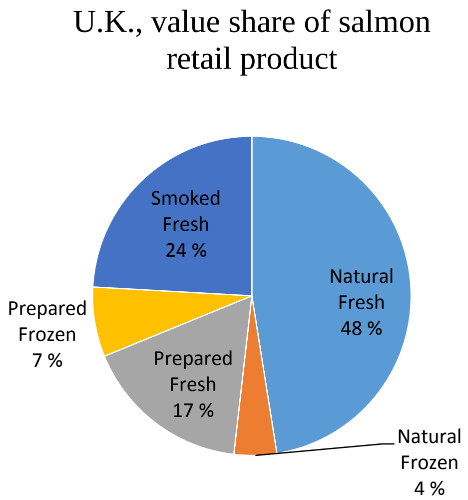


Figure 3. Retail value shares of main salmon products, France and U.K. 2013
(source: Europanel)

Table 1 lists the retail products available and reports summary statistics for each price variable for France and U.K. The French retail market makes a distinction between products arriving without any packaging (non-prepacked) and packaged (prepacked) products supplied by seafood producers. Packaged salmon products are on average higher priced than its counterparts sold in the fresh seafood counter. The table shows great variation in products and prices with fresh/frozen fillet and fresh whole least expensive and processed smoked salmon most expensive. For U.K., notice the very low price of ready main meals, which includes fish and other food components[10]. The coefficient of variation (CV) provides measurement of the volatility of the price series relative to the mean. We observe good variation in prices across the different products except for some products in the French market i.e., fresh steak, frozen fillet, and ready main meals, which may reflect retail marketing strategy.

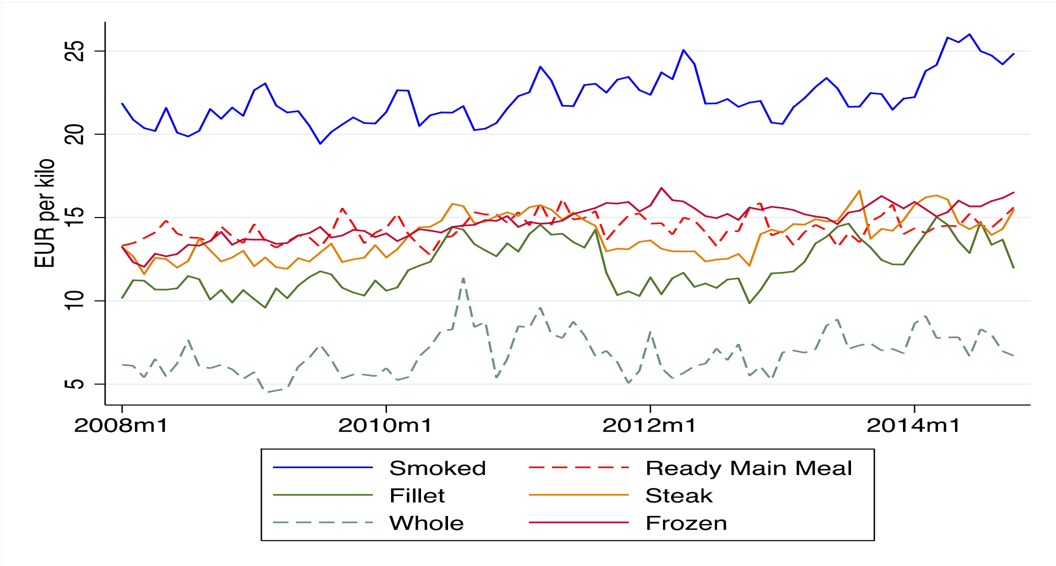
TABLE 1. Summary statistics retail prices: France (2008-2015), U.K. (2005-2015)

	Mean	Std. Dev.	Min	Max	CV
France					
Fresh fillet[a]	12.06	1.48	9.59	15.04	0.12
Fresh fillet[b]	15.62	1.83	12.24	19.77	0.12
Fresh steak[a]	13.86	1.27	11.61	16.61	0.09
Fresh steak[b]	16.44	1.36	13.76	18.96	0.08
Fresh whole[a]	6.824	1.28	4.49	11.39	0.19
Frozen fillet[b]	14.74	1.03	12.05	16.78	0.07
Frozen steak[b]	14.47	1.75	10.19	17.74	0.12
Smoked fresh[b]	22.13	1.46	19.43	26.01	0.18
Ready main meal	14.37	0.74	12.75	16.12	0.05
U.K.					
Fresh fillet	13.59	1.49	10.70	16.29	0.11
Fresh whole	7.546	1.95	3.75	13.56	0.26
Frozen fillet	10.39	1.08	7.93	12.94	0.10
Fresh add value	13.44	1.66	10.87	18.37	0.12
Fresh breaded	9.118	0.84	7.12	11.71	0.09
Frozen fish in sauce	11.67	2.53	6.51	15.82	0.22
Smoked fresh	22.58	2.75	16.77	28.50	0.12
Ready main meal	6.56	0.69	5.27	8.97	0.11

[a] Non-prepacked products
[b] Prepacked products

Finally, to provide a visual guide to the trend of retail prices overtime we graph out, in Figure 4, selected products for the French and U.K. markets. For both markets we observe the premium received for smoked salmon, but overall, except for whole fresh, retail prices in France seem stable with a positive trend. The U.K. market also shows a positive trend but breaded and sauce products are virtually flat over the period, showing little or no trend or monthly variation.

France



U.K.

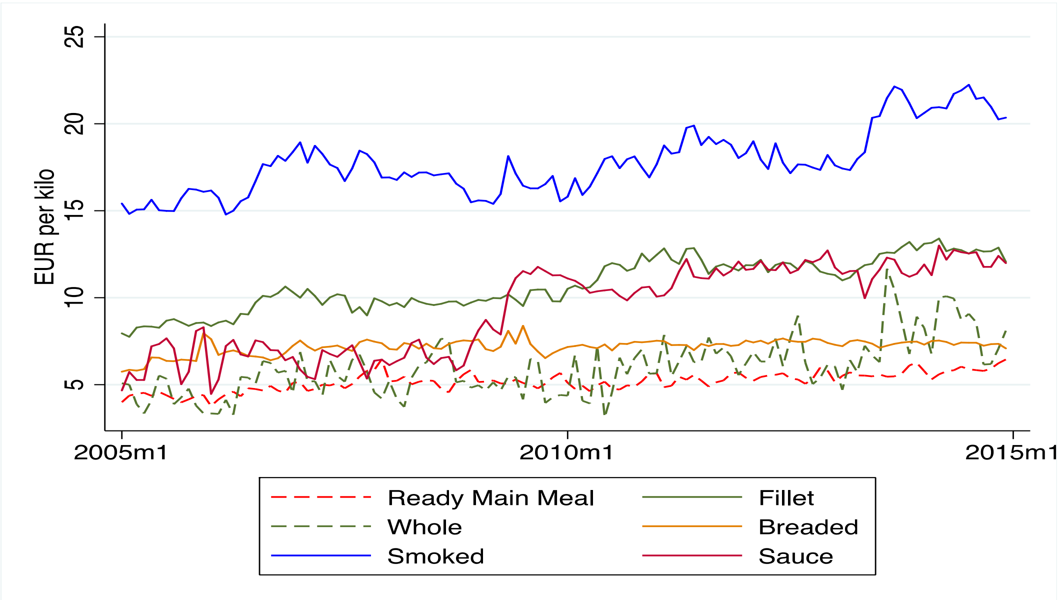


Figure 4: Select retail prices French and U.K. markets (source: Europanel)

Model

Based on work by Richardson (1978) and Asche, Menezes, & Dias (2007) it is common in the price transmission literature[11] to model prices in the supply chain as log linear and defined on the downstream price as:

$$lnP_{r,t} = \hat{\alpha} + \hat{\beta} lnP_{e,t} + e_t, \quad (1)$$

where $P_{r,t}$ and $P_{e,t}$ are the current prices in the retail and export market, respectively. Marketing costs are assumed constant and included in the intercept term. All other factors impacting price are assumed random and collected in the error term, e_t. Complete price transmission implies that $\hat{\beta} = 1$, so that any change in price is fully transmitted to the retail price.[12] Moreover, if $\hat{\beta} = 1$ the intercept, $\hat{\alpha}$ is defined as the cost mark-up between the two sectors in the supply chain. On the other hand, if $\hat{\beta} = 0$ there is no relationship between the prices and, perhaps most importantly for empirical work, if $0 < \hat{\beta} < 1$ there is a relationship between the prices but price transmission is incomplete.

Although equation (1) looks relatively simple and straightforward, econometric estimation is often complicated by non-stable probability distributions of the price variables and violation of the conditional expectation condition $E(e_t|P_{e,t}) \neq 0$ (i.e., enodgeneity with the price variable being correlated with the random error term (Gordon 2015)). The first condition is common with economic variables where the parameters of the probability distribution are not covariance stationary and change over time. If this issue is not accounted for parameter estimates are spurious (i.e. the results look statistically good but are meaningless). Whereas, the second condition violates the main assumption of econometrics (i.e., endogenous regressor) and causes inconsistent parameter estimates[13].

Standard regression analysis requires that the probability distribution of each variable in the regression be stable or stationary overtime (i.e., covariance stationary). In other words, for each variable all moments of the distribution are constant; constant mean, variance, and covariance. In economics, most price variables are nonstationary in levels and the parameters of the probability distribution change over time. However, in many cases a simple first-difference transformation regains stability. There are a number of tests to evaluate the stochastic properties of time-series variables but the augmented Dickey-Fuller (ADF) test[14] and generalized least squares Dickey-Fuller (glsDF) tests are commonly used (Elliott et al., 1996; Gordon, 1995; Dickey and Fuller 1979). The ADF is a test of the null hypothesis that the price series is stationary in first-differences with the alternative hypothesis stationary in levels[15]. The glsDF follows the same hypothesis except that the price series is first transformed by a generalized least squares procedure before the DF test. The glsDF has more power than the DF procedure alone to detect near stationary series.

If price variables test non-stationary the problems noted above apply, however, it is still possible for equation (1) to be statistically and economically relevant if there exists a parameter vector that forces the error term to be stationary. This is the time series notion of cointegration and the economic notion of long-run equilibrium. A straightforward procedure would be to run least squares on equation (1) and test the predicted errors for properties of stationarity[16]. The problem with such an approach is that it does not address the endogeneity problem and the fundamental conditional expectation condition is not satisfied. (Basically, do you define the retail or export price as the dependent variable in equation (1)?) The Johansen cointegration procedure (Johansen 1988, 1991) avoids the problem of endogeneity by using a vector autoregressive estimation framework[17]. In other words, no prior assumption on exogeneity is required. The Johansen procedure is capable of handling a multivariate system of non-stationary variables in a way that produces statistically valid test results (Johansen, 1988; Dickey, Jansen, and Thornton, 1991). The estimated equations recover both the long-run parameters that can be interpreted as the mechanism that forces the system to regain the equilibrium (i.e., cointegration) and adjustment parameters that can be interpreted as the speed of adjustment to equilibrium.

In the Johansen framework, co-integration can be tested based on the eigenvalues (λ) of the maximum-likelihood estimation (Johansen and Juselius, 1991) i.e., the maximum eigenvalue test (λ max) and the trace test (λ trace)[18]. The null hypothesis for both is that there are a maximum k cointegration vectors. However, for the max test the alternative is more than k cointegration vectors, while for the trace test there are $k + 1$ cointegration vectors. Toda (1994) argues that in a bivariate setting the trace test is to be preferred[19]. Moreover, Cheung & Lai (1993) argue the trace test shows more robustness against skewness and excess kurtosis in the error. Both tests are a modified Chi-squared statistics. In addition, we will also apply a minimization technique describe in Gonzalo and Pitarakis (1998) and Aznar and Salvador (2002). These papers discuss the use of information criterion to pick the optimal number of cointegrating vectors[20]. This technique is very similar to the rule used to pick lag length in Dickey-Fuller statistics and provides an alternative to the Chi-squared testing to test for cointegration in our price variables.

The estimated equations also recover useful information on exogeneity or price leadership (Johansen, 1988) (i.e., do changes in retail prices lead to changes in export prices?). This will give valuable information about whether it is demand and supply shocks in the export market that are the drivers of price change downstream in the value chain. Price leadership can be analyzed by testing for weak exogeneity in a VAR framework where there are two or more prices involved.

Our empirical strategy is first, to search for optimal lag length in setting Dickey-Fuller statistics second, to test each price variable for stationarity using both the ADF and glsDF procedures[21], finally, estimate and test for cointegrating vectors using the Johansen procedure and test for price transmission and price leadership.

Results

Gordon (1995) argued that setting the lag length in Dickey Fuller statistics is important in hypothesis testing. To investigate the correlation for each price variable and set lag length for testing using both Akaike's Information Criteria (AIC) and Baysian Information Criteria (BIC).[22] The results are reported in Table A1 in the Appendix. Interestingly, the results for France set very short lag lengths of one or two lags even for heavily processed products.[23] On the other hand, for the U.K. it appears past correlation is important and we see lag structure of three or four periods. In general, the AIC and BIC results are consistent but where they diverge we rely on the BIC statistic but, nevertheless, we do check for consistency in stationary testing using both procedures.

Table 2 reports the results of the ADF (with trend) and glsDF tests for unit root testing for export and retail prices in both the French and U.K. markets. Each price variable is first transformed using the natural logarithm. Columns 2 and 3 report results using the level series under the ADF and glsDF tests, respectively. Column 4 repeats the glsDF test using the first-difference of the variables and the second order hypothesis procedure.

For both the French and U.K. markets we observe that export prices test first-difference stationary using both the ADF and glsDF tests and this is confirmed using the second order test reported in column 4. Retail prices for both countries show mixed results. Using the French data, fresh fillets and steaks, and frozen fillet, test stationary in first-differences (confirmed by the second order test), however, fresh whole, frozen steak, smoked and ready main products test stationary in levels. For U.K. retail prices, fresh and frozen fillet, sauced, smoked and ready main products test first-difference stationary (confirmed by the second order test), whereas, fresh whole and added, and breaded test stationary in levels. The results are consistent under either the ADF of glsDF procedures.

TABLE 2. Stationary; Dickey-Fuller and Generalized Least Squares Dickey-Fuller

	ADF[a]	glsDF[b]	glsDF[c]
France			
Export:			
Fresh fillet	-1.75	-2.17	-4.53*
Fresh whole	-2.44	-2.69	-3.85*
Retail:			
Fresh fillet[d]	-2.29	-2.48	-5.11*
Fresh fillet[e]	-2.19	-2.12	-5.03*
Fresh steak[d]	-2.12	-2.44	-5.79*
Fresh steak[e]	-1.93	-1.93	-4.30*
Fresh whole[d]	-3.45+	-3.53+	-6.96*
Frozen fillet[e]	-2.05	-2.88	-4.47*
Frozen steak[e]	-3.15+	-4.54*	-4.49*
Smoked fresh[e]	-3.88+	-3.39+	-6.96*
Ready main meal	-4.99+	-4.21*	-7.38*
U.K.			
Export:			
Fresh fillet	-1.89	-2.66	-4.80*
Fresh whole	-2.17	-2.26	-5.66*
Retail:			
Fresh fillet	-1.67	-1.88	-3.92*
Fresh whole	-4.83*	-3.91*	-6.22*
Frozen fillet	-2.06	-2.16	-5.55*
Fresh added value	-6.68*	-3.73*	-5.16*
Fresh breaded	-4.91*	-3.28+	-8.53*
Frozen in sauce	-1.65	-1.82	-3.76*
Smoked fresh	-1.99	-2.86	-7.90*
Ready main meal	-1.61	-2.77	-5.50*

[a] p-value on augmented Dickey-Fuller with trend, test in levels.
[b] glsDF test statistic in levels
[c] Null hypothesis is stationary in second-differences with an alternative of stationary in first-differences, glsDF test statistic
[d] Non-prepacked products
[e] Prepacked products
+statistically significant at 5% level
* Statistically significant at 1% level

The stationary results are somewhat odd in that we would normally expect price variables to be first difference stationary and not stationary in levels (i.e., covariance stationary). This may be the result of the retail sectors attempt at stabilizing consumer prices.

But it does not explain why some retail prices are stationary and others not. It is worthwhile to look a little closer at the stationary properties for those variables rejecting the null of stationary in first-differences in favour of the alternative hypothesis of stationary in levels. Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) (1992) develop an alternative stationary test that flips the role of the null and alternative hypotheses i.e., a null hypothesis of stationary in levels against the alternative of stationary in first differences[24]. This test has shown to be particularly useful where the price variable is judged to be stationary. Setting optimal lag length in testing is again an important issue and for the KPSS test we use the bandwidth selection procedure described in Hobijn et al. (1998).[25] Table 3. Reports the results of the KPSS test for all price variables that test stationary in Table 2.

TABLE 3: KPSS Test for Stationary Series

	Fresh Whole[a]	Frozen Steak[a]	Smoked Fresh[a]	Ready Made Meals[a]	Fresh Whole[b]	Fresh Added Value[b]	Fresh Breaded[b]
Test Statistic	0.086	0.107	0.066	0.147^{+}	0.118	0.226*	0.235*
Lag Length	6	4	6	5	6	6	7

[a] French retail market
[b] U.K. retail market
$^{+}$ Statistically significant 5% level
* Statistically significant 1% level

First thing to note of Table 3 is the substantial lag length chosen by the Hobinj et el. lag procedure compared to the AIC/BIC listed in Table A1. Under the null of the KPSS test we do not reject stationary in levels for fresh whole, frozen steak and smoked fresh in France and fresh whole in U.K.[26]. However, the KPSS provides a rejection of the null at the 5% level with the alternative being stationary in first differences for ready main meals in France and fresh added value and breaded in U.K. In other words, the KPSS provides evidence that three additional price variables are stationary in first differences and amenable to further regression analysis in a price transmission framework. Our strategy is to accept the KPSS results and to bring forward for cointegration testing all price variables testing first-difference stationary in Tables 2 and 3.

Variables testing stationary in levels are not considered for cointegration testing. The problem for cointegration analysis was pointed out by Granger (1981), he noted that in a bivariate regression it is not possible to include both covariance and first-difference stationary variables (i.e., the equation is not 'balanced' and thus the probability distribution of the resulting errors is unknown). Thus, in a bivariate regression using variables integrated at different levels, cointegration (i.e., long-run equilibrium) is not possible

It is worth mentioning, however, that for stationary retail prices where a long-run cointegrated equilibrium relationship with export prices is excluded, a short-run relationship may still exist. Certainly, if the price of a major input (farmed fish) increases this will impact the cost component of the retail product regardless of the non-cointegration status. What the non-cointegration result tells us is that retail prices can drift apart in the long run from the export price of farmed fish with no natural tendency to regain the equilibrium. We turn now to report the results of the bivariate Johansen tests.

Test results for the Max and Trace tests, and Information Criterion for cointegration are reported in Table 4.[27] In specification, seasonal dummies are included to account for a fixed seasonal pattern that could be present in the price movements. Bivariate regressions are specified for each retail product against the export price of whole salmon. For France, all test statistics show evidence of one cointegrating vector for all retail products except frozen fillet. For the U.K. market we observe evidence for one cointegrating vector for fresh fillet, fresh breaded and smoked fresh, whereas, frozen fillet, fresh added value, frozen sauce and ready main meals show no long-run relationship.

TABLE 4 Bivariate Johansen Cointegration Tests

Export price Salmon	Maximum Eigenvalue[a]	Trace[b]	Minimizing Information Criterion[c]
French[d]			
Fresh fillet[e]	41.29	46.14	-5.292
	4.86*	4.85*	k=1
Fresh fillet[f]	20.81	23.97	-5.282
	3.17*	3.17*	k=1
Fresh steak[e]	29.23	33.59	-5.60
	4.36*	4.36*	k=1
Fresh steak[f]	30.02	33.47	-5.825
	3.45*	3.45*	k=1
Frozen fillet[f]	5.67	9.14	-1.086
	3.46	3.46	k=0
Ready main meal	26.27	29.84	-5.132
	3.57*	3.57*	k=1
U.K.[g]			
Fresh fillet	17.88	20.54	-6.170
	2.66*	2.66*	k=1
Frozen fillet	10.37	136.34	-5.423
	2.96	2.96	k=0
Fresh added value	6.51	8.47	-5.204
	1.96	1.96	k=0
Fresh breaded	19.69	23.00	-5.752
	3.23*	3.23*	k=1
Frozen in sauce	9.42	12.35	-3.932
	2.93	2.93	k=0
Smoked fresh	24.25	26.20	-5.26
	1.94*	1.94*	k=1
Ready main meal	7.43	9.34	-5.419
	1.90	1.90	k=0

[a] Hypothesis Null: k=i cointegration vectors, Alternative: k> i cointegration vectors
[b] Hypothesis Null: k=i cointegration vectors, Alternative: k+1 cointegration vectors
[c] Selecting the number of cointegration vectors by minimizing information criterion
[d] Number of observations=80
[e] Non-prepacked products
[f] Prepacked products
[g] Number of observations=118
* Statistically significant at the 1% level

What do we make of these results? On the one hand, we do observe a long-run relationship of the export price of salmon and fresh retail product, although this does not hold true for all fresh retail product (i.e., fresh value added). For most retail fresh products, prices can drift apart from export prices in the short run but respond to positive and negative shocks to maintain the relationship in the long run. Given the perishable nature of fresh salmon, this seems reasonable, as retail input costs must be covered for spoilage and to maintain economic viability. Given that the storage property of frozen product lessens the time constraint on sales, the evidence here shows that frozen product does not maintain a long-run link to export prices. One surprising result is that ready main meal in France shows long run links to export prices that is absent in the U.K. market; the result perhaps of particular marketing strategy in U.K.

Table 5 extends our investigation of cointegrated prices in the salmon supply chain. Column two reports the p-value on the likelihood ratio test of a null of full price transmission. Column three reports the long-run price transmission elasticity and column four shows the results of a test of price leadership.

TABLE 5 Model Evaluation and Price Transmission Elasticity

Export price Salmon	Full Price Transmission[a]	Price Transmission Elasticity-Long run	Weak Exogeneity[b]
French[c]			
Fresh fillet[d]	0.000	0.695 (0.037)[e]	46.74[+] 0.799
Fresh fillet[h]	0.000	0.646 (0.055)	13.06[+] 2.39
Fresh steak	0.000	0.508 (0.032)	43.99[+] 1.77
Fresh steak[h]	0.000	0.464 (0.34)	26.52[+] 0.002
Ready main meal	0.000	0.085 (0.045)	25.16[+] 0.652
U.K.[i]			
Fresh fillet	0.213	0.792 (0.129)	14.97[+] 3.69
Fresh breaded	0.000	0.058 (0.076)	18.68[+] 0.01
Smoked fresh	0.000	0.611 (0.117)	17.08[+] 0.281

[a] First value is Null, retail price leadership, second value is Null, export price leadership with Chi-square statistic(1)

[b] Number of observations=80
[c] Non-prepacked product
[d] Null Hypothesis is full price transmission: p-value
[e] standard error
[h] Prepacked product
[i] Number of observations=118
[+] Statistically significant at the 5% level

For column two, in all cases except fresh fillet in U.K., the p-values are very small providing statistical support to reject the null hypothesis of full price transmission. These results seems rather surprising given the many fresh retail product forms tested for these markets. A priori one might expect fresh retail product to respect and fully respond to price shocks from the export level. But the results reported with this data set show quite strongly that the retail price is cushioned from complete price pass through from the export level. These results certainly support the idea that a fundamental retail strategy is to follow a smooth price projection for retail products.

We can push this a little further by looking at the estimated price transmission elasticity report in column three. We report relatively large (but less than 1) elasticity values for all French products except ready main meal. This shows that although we reject full price transmission, in many cases, much of the export price shock is passed on to retail prices. On the other hand, ready main meals, which reflect a variety of raw material inputs in addition to salmon, measure a price transmission elasticity of only 0.085. Clearly for this product the raw fish product does not have a demanding impact on final retail price. For the U.K. the story is much the same but in this case it is breaded product measuring a very small price transmission elasticity (0.058). It is worth pointing out that the only product testing positive for full price transmission (U.K. fresh fillet) actually reports a price elasticity of 0.8. Of course, the statistical test accounts for the standard error (0.12) that forces the positive result. We also note that price transmission to retail prices decreases as more processing is involved. The econometric results further suggest that transmission is higher for retail prices of salmon products sold in the fresh fish counter compared to prices of packaged salmon products. This suggests higher marketing costs for packaged products.

The test of weak exogeneity reported in column four of Table 5 is a long run test of price leadership. This is an interesting test as the results will provide important information for policy leaders as to the important node in the supply chain for policy instruments to directly impact the market; i.e., taxes or subsidies. Notice that for each retail product, the first test value is for the null of retail price leadership and the second test value is the null of export price leadership. In all cases, we reject the null hypothesis of retail price leadership but cannot reject the null hypothesis of export price leadership. In other words, export price is weakly exogenous to our model and, moreover, the econometric specification listed in equation (1) is in fact correct. Our data and statistical results support price causality from the export level to retail level in both France and U.K., even though full price transmission is not complete.

Conclusion

In this paper we have measured and tested for price transmission and price leadership in the salmon supply chain. The empirical analysis is based on Norwegian export prices of fresh salmon and retail prices of processed and semi-processed salmon products in the French and U.K. markets. The research presented here carries out time series testing on a broader set of consumer salmon products compared to what have been used in earlier studies.

Of the original 17 retail products examined only 8 cointegrate with export prices. The nine products failing cointegration do so either because of covariance stationary probability distributions, which are at odds with the first-difference probability distributions characterizing Norwegian export prices or lack long-run equilibrium conditions. Of those retail prices cointegrated with export prices our results show only one case (fresh fillet in the U.K. market) where we measure full price transmission. Nevertheless, most natural fresh products such as fillets and steaks do show a high degree of price transmission from Norwegian export prices to retail prices. These products account for almost a third of retail sales by value in France and almost half of sales in U.K. Interestingly, the added value products ready main meals in France and fresh breaded in U.K. show a very low value of price transmission. Nonetheless, in all products testing cointegrated with export prices we do measure price leadership from export prices to retail prices.

The results suggest that packaging (i.e., Styrofoam type packaging) of fresh salmon products appears to reduce price transmission elasticity. Fresh salmon fillets on ice have a price transmission of 0.7 compared to those for fresh fillets sold in Styrofoam packaging of 0.65. However, the relationship between the magnitude of marketing costs and price transmission does not appear to be straightforward; e.g., for a product with a high markup like fresh smoked salmon the price transmission from fresh salmon raw material remains significant. This seems to be linked to relatively few inputs involved where it is the cost of the salmon raw material that creates the largest variation in the overall costs of the final product.

Furthermore, our results also suggest that in France price transmission is higher for retail prices of salmon products sold in the fresh fish counter compared to prices of salmon products sold with packaging; likely the result of higher marketing costs. The results presented here are consistent with the general finding that price transmission lessens with the degree of value added.

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APPENDIX

TABLE A1. Optimal Lag Length: Akaike's Information Criterion and Bayesian Information Criterion

France	AIC[a]	BIC[b]
Export:		
Fresh fillet	2	1
Fresh whole	2	2
Retail:		
Fresh fillet[c]	1	1
Fresh fillet[d]	2	1
Fresh steak[c]	1	1
Fresh steak[d]	2	1
Fresh whole[c]	1	1
Frozen fillet[d]	2	1
Frozen steak[d]	4	1
Smoked fresh[d]	1	1
Ready main meal	1	1
U.K.		
Export:		
Fresh fillet	1	1
Fresh whole	2	2
Retail:		
Fresh fillet	3	3
Fresh whole	3	3
Frozen fillet	3	3
Fresh added value	4	4
Fresh breaded	1	1
Frozen in sauce	3	3
Smoked fresh	1	1
Ready main meal	4	3

[a] Akaike's Information Criterion
[b] Bayesian Information Criterion
[c] Non prepacked products
[d] Prepacked products

Notes

[1] These attributes also provide new margins to optimise over (Asche et al, 2015).
[2] In recent years, there has been an increasing interest in price transmission for seafood. Some recent studies are Dey et al. (2015), Gordon and Hussein (2015), Gordon and Maurice (2015), Singh (2016) and Tveteras (2015).

[3] Fofana and Jaffry (2008) report the share of fresh fish sold through supermarket chains has increased from 16% in 1988 to 86% in 2003. They argue that increased concentration has led to supermarkets exerting greater influence on suppliers.
[4] Export price data provided by Norwegian Seafood Council and retail prices obtained from household surveys collected by EuroPanel.
[5] We thank Kristin Lien for providing data.
[6] Primary data source is Europanel (http://www.europanel.com/)
[7] To be complete and show a reference comparison we report export values of both fresh whole and fresh fillet.
[8] The standard deviation for both products is 0.74 with a coefficient of variation (CV) of 0.117 and 0.176 for fillet and whole, respectively.
[9] The standard deviation for fresh fillet is recorded at 1.17 and for fresh whole 0.69 with a coefficient of variation (CV) of 0.189 and 0.176, respectively.
[10] Some processed products may include the less expensive wild caught pink salmon.
[11] See, Guillotreau et al., 2005; Asche, Jaffry, & Hartmann, 2007; Larsen & Asche, 2011; Simioni et al., 2013; Asche et al., 2014.
[12] See, Asche, et al (2002) for a detailed description of price transmission.
[13] This implies that $\lim_{t\to\infty} \hat{\beta} \nrightarrow \beta$. A referee points out that *'for the bivariate model like the equation (1), when the variable on the right hand side is weakly exogenous the OLS estimation is unbiased or super convergent'*.
[14] Based on Figure 4, we impose a trend in ADF testing; the default in glsDF is trend stationary.
[15] The second order test has a null of stationary in second differences with an alternative of stationary in first differences.
[16] This is the standard Engle-Granger procedure (Engle and Granger, 1987).
[17] Each price variable is regressed only against lagged values of own and other price variables.
[18] The trace test is written $J_{trace} = -T\sum_{i=r+1}^{n} ln\left(1-\hat{\lambda}_i\right)$ and maximum eiqenvalue $J_{max} = -Tln\left(1-\hat{\lambda}_i\right)$.
[19] For the max and trace test in a bivariate setting, the test values differ only for the null of zero conintegrating vectors.
[20] Stata 12 has a convenient command (*ic*) to generate both the BIC and Hannan and Quinn criterion.
[21] The sequence is first to carry out the test in level form and then based on non-rejection of the null carry out a second order test based on first-difference of each variable.
[22] Stata 12 has a useful time series command *varsoc* to pick lag length.
[23] This is somewhat surprising since most seafood prices tend to be nonstationary (Asche and Oglend, 2016; Oglend and Asche, 2016).
[24] This test has power against series that are integrated less than one.
[25] Hobijn et al. (1998) argue their procedure for lag length showed the best small sample test performance in Monte Carlo simulations. This procedure is programmed in Stata 12 using the *auto* command for the KPSS test.
[26] Although it seems odd that export and retail prices of fresh whole salmon follows different stationary processes, this may be explained by the thin volumes of fresh whole salmon in supermarkets.
[27] Lag length for the VAR component of the cointegration tests are defined using a variety of selection order criteria (FPE, AIC, HQIC SBIC) defined in STATA. The purpose is to obtain a VAR fit that minimizes the residual sum of squares with statistically acceptable residuals.

Salmon trout? The forgotten cousin

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Salmon trout? The forgotten cousin

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Abstract This study investigates potential economic reasons why production of trout is maintained in Norway by analyzing prices and production for Norwegian Atlantic salmon and trout. The species Atlantic salmon dominates the global salmon market, but its two largest producers, Norway and Chile also farm in sea pens significant quantities of large rainbow trout (as opposed to portion-sized Rainbow trout farmed in fresh waters in other parts of the World, e.g., Iran, Peru, Turkey and others), suggesting that this trout have some attributes that makes it a useful complement to Atlantic salmon. We investigate development in supply volumes of these species and conduct a cointegration analysis using monthly prices from 2000 to 2018. The results show that the markets for fresh and frozen rainbow trout are tightly integrated with fresh Atlantic salmon, and, where the latter is a price leader. This means that many consumers consider the two products as substitutes, with no clear preferences. There are no apparent productivity argument for the continued production of rainbow trout vis-à-vis Atlantic salmon, However, there may exist a fringe of consumers that prefer its characteristics, motivating firms to maintain its production as a means of diversification.

Keywords: Atlantic salmon, rainbow trout, market integration, cointegration

1. Introduction

Salmon is among the most successful aquaculture species globally in terms of production growth, and it is the second most valuable group of aquaculture species after shrimp (Anderson et al., 2018; 2019; Garlock et al., 2020). Most studies of the salmon market focus on Atlantic salmon, which has become the leading species, largely overlooking that a number of other salmonids are also farmed, although in smaller quantities. These includes rainbow trout, coho, chinook and arctic char. Somewhat surprisingly, the two largest producers of Atlantic salmon, Norway and Chile, also produce significant quantities of large rainbow trout, suggesting that this trout have some attributes that makes it a useful complement to Atlantic salmon. In this paper we will look at prices and production for Norwegian Atlantic salmon and trout to investigate potential economic reasons for why production of trout is maintained.

With the exception of rainbow trout, the farmed salmon species all have in common with Atlantic salmon that they are farmed in relatively few countries. Rainbow trout is an exception in that it is farmed in two very different production systems and in a large number of countries. Together with a few other countries such as Chile and Finland, Norway produce the rainbow trout in salt water in net pens similar to Atlantic salmon, giving a fish that is harvested at similar weights (about 5 kg) as Atlantic salmon and with red flesh. This contrasts strongly with the pond based, white fleshed portion sized trout that are produced in most other countries. As a result, the large red trout is often known as salmon trout.

Nielsen et al. (2007: 2011) show that the portion sized rainbow trout is not a part of what is normally referred to as the salmon market, but rather is on the fringe of the whitefish market. Virtanen et al. (2005) indicate that the salmon trout, at least in Finland, is a close substitute to Atlantic salmon. Tveteras and Asche (2008) show that there is a well-integrated market for what they label as the red fleshed salmons in Japan, i.e. farmed coho and salmon trout and wild sockeye. These species are distinguishable from Atlantic salmon by their redder flesh. This provides one market argument for the salmon trout, in that it's color is closer to the wild Pacific species that traditionally dominated the Japanese market. Alfnes et al. (2006) and Forsberg and Guttormsen (2006) discuss how different markets have varying preferences for the color of the salmon flesh. Japan having a preference for the reddest color, while in several European markets there was a lower willingness to pay among consumer for the reddest salmon.

There are a number of potential market based economic hypothesis with respect to why some farmers may choose to farm salmon trout instead of, or in addition to, Atlantic salmon in Norway. The discussion with respect to flesh color provides one, in that a redder flesh color can make the species particularly suitable in some specific markets, allowing the salmon trout to segment itself away from Atlantic salmon. There may also be other factors contributing either to a price premium or less price volatility. An important feature of the salmon trout production is that a much higher share than what is the case for Atlantic salmon is shipped as frozen, a feature that follows from a stronger biological growth cycle. Asche and Bjørndal (2011) argue that one of the main advantages of Atlantic salmon is that it grow more evenly over the year, making it economically feasible to harvest the fish year around. This is important since it also allows for more consistent marketing efforts, better capacity utilization in logistics and distribution, as well as better coordination (Asche, Roll and Tveteras, 2007; Kvaløy and Tveteras, 2008; Olson and Criddle, 2008; Asche, Cojocaru and Roth, 2018).

Other economic aspects and biological factors that directly or indirectly influence production cost will not be a part of the scope of this paper. There is a large literature on productivity growth and cost development in Norwegian salmon aquaculture (e.g. Rocha-Aponte and Tveteras, 2019; Roll, 2019; Iversen et al., 2020). Trout data is a part of the data sets used here, but it is not possible to separate trout production from salmon production.

2. Salmon production

In 2017, global production of rainbow trout was over 751,652 thousand metric tons (mt), of which 147,453 mt took place in Chile, Finland and Norway.[2] Hence, the production of salmon trout was 147,453 mt in 2017, and this is the part of the rainbow trout production that will be counted as a part of the global salmon production in this paper due to its market position. Chile was the largest producer with 76,971 mt followed by

[2] In the 1980s, Finland also produced portion sized trout, but this is excluded here based on estimates from Kontali Analyse. Portion sized trout is the largest aquaculture species in a number of European countries (Guillen et al., 2019; Lloriente et al., 2020).

Norway with 66,902 mt. Hence, the production of salmon trout is dominated by two countries, with Chile as the largest producer in recent decades.

Figure 1 show global salmon production by species. From figure 1 it is evident that production has been rapidly increasing, that Atlantic salmon is the main species, there is significant production of salmon trout and coho, a small production of chinook and that other species are too small to be considered. In 2017 total production was 2.7 million mt, Atlantic salmon made up 86.4%. Salmon trout made up 5.8% of the total production with 157.3 thousand mt, and 2000 was the first year since 1992 that coho production was larger than salmon trout with a quantity of 199.6 thousand mt. This is largely due to a rapid increase in Chinese production that has allowed them to take over Japan as the second largest producer, but Chile is still by far the largest producer of coho.

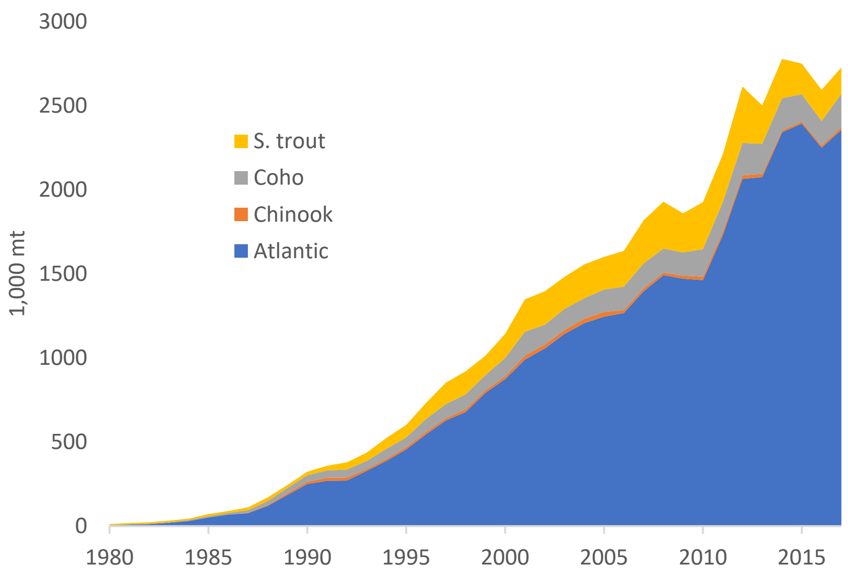

Figure 1. Global salmon production by species

Source: FAO (2020)

The dominance of Atlantic salmon is relatively recent as can be seen from Figure 2, where the production shares of the four species are shown. In fact, in 1980 production of salmon trout was larger than the production of Atlantic salmon. With a quantity of 5.6 thousand tonnes salmon trout made up 45.8% of total production, while the share of Atlantic salmon was 39.0%. Norway was the largest producer of both salmon trout and Atlantic salmon, with trout having a strong knowledge background as it was largely knowledge from trout production that created the salmon farming industry together with the introduction of the sea pen (Nielsen et al., 2016). Japan largely developed coho farming independently and was the largest producer of coho.

In the 1980s the production share of Atlantic salmon increased rapidly to over 70%, a level where it was relatively stable until the 2010, when it started to increase again and it has been around 85% in the last few years. During this period the production share of salmon trout fell rapidly, and before 2017, 1990 was the year with the lowest production share. Hence, salmon trout also lost share to coho and even chinook. During this period Finland took over as the largest producer of salmon trout. In the early 1990s the production share of salmon trout increased again, particularly due to increased production in Chile who overtook Finland as the largest producer in 1994. Production was also increasing in Norway, who overtook Finland as the second largest producer in 1997.

In Figure 3, Norwegian production of salmon is shown. Also here Atlantic salmon dominates, but also in Norway this is a recent phenomenon in that the production share of salmon trout was as high as 46.9% in 1980.[3] Production remained stable at around 5,000 mt in the 1980s. It declined to as little as 2.2% in 1990 as production was reduced to 3,796 mt before it rebounded. Production of salmon trout increased to 77 thousand mt in and a production share of 14.8% in 2002, the highest in the 2000s. Since then production has varied between 54 and 87.8 thousand mt around a stable mean. The highest production level, 87.8 thousand mt, was reached as late as 2016.

[3] Salmon trout is regulated together with salmon in Norway, and producers are free to chose which of the species to produce (Asche and Bjørndal, 2011). Hence, there are no regulatory advantages associated with the production of salmon trout, and there do not appear to be any environmental advantages either (Tveteras, 2002; Torrissen et al., 2011; Abate et al., 2018).

While the production of salmon trout is moderate compared to salmon, it is still important in a Norwegian seafood sector dominated by salmon. On the top 10 list of exported products in the period 2004-2014, there are 4 salmon products, with fresh salmon and fresh salmon fillets occupying the two top spots (Straume et al., 2020). Whole fresh trout occupies the 10th spot and whole frozen trout the 16th spot.

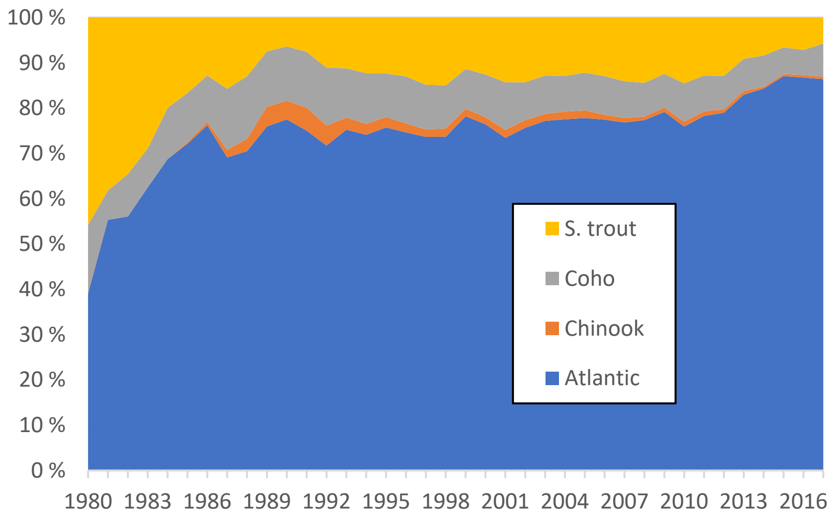

Figure 2. Global salmon production shares by species
Source: FAO (2020)

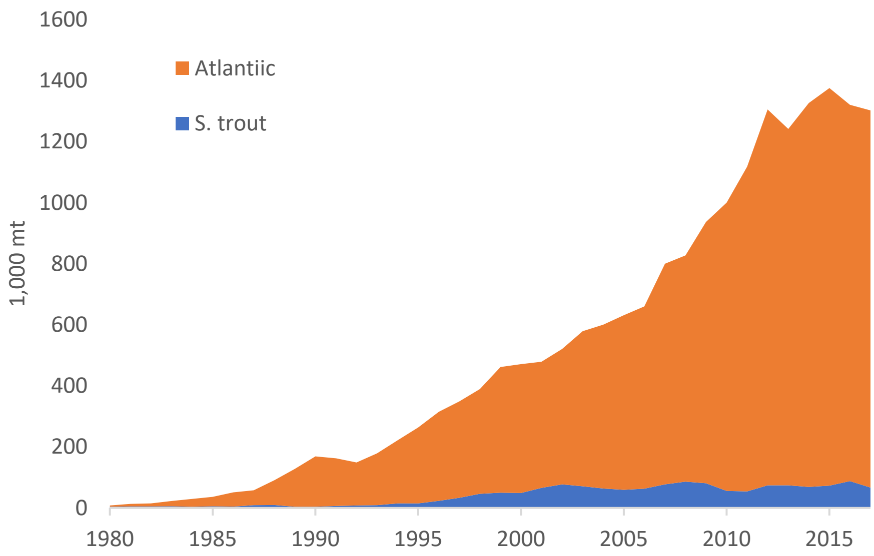

Figure 3. Norwegian salmon production by species
Source: FAO (2020)

3. Market integration analysis

A market integration analysis will be conducted for the two most important product forms of salmon trout and whole Atlantic salmon.

3.1 Data

The market integration analysis is based on monthly Norwegian exports of Atlantic salmon and rainbow trout products from January 2000 through December 2018. Export prices of fresh and frozen whole rainbow trout together with fresh whole Atlantic salmon are shown in Figure 4. As can be seen the prices appears to be highly correlated. This gives a clear indication that these prices share a common price determination process.

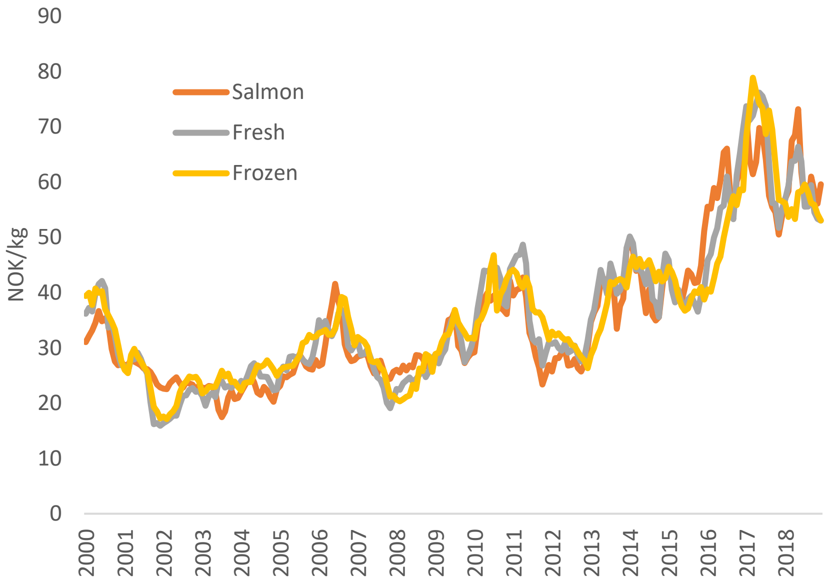

Figure 4. Monthly export prices of fresh and frozen whole salmon trout and of fresh whole Atlantic salmon

Source: Norwegian Seafood Council

Table 1 shows descriptive statistics. There is not much differences in the mean price levels of the three prices. The two trout prices have a slightly higher price level than fresh salmon, but the difference is not statistically significant and is small enough to not create any strong price incentives for producing trout. However, the premium is high enough to justify a slightly higher production cost if that is the case.[4][5] It is also of interest to note that the price of fresh trout is higher than the frozen trout price despite the labor and energy that goes into the freezing process, supporting the notion that the ability to supply of fresh fish gives the highest value to the producer (Roheim et al., 2007). The coefficient of variation is exactly the same for fresh whole trout and fresh salmon, and slightly higher than for the storable product frozen trout. Hence, trout appear to have neither an advantage nor a disadvantage relatively to salmon with respect to price risk.[6]

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[4] The Directorate of Fisheries does not break down their production cost data by species, and there is accordingly no information available with respect to the production cost for trout relatively to salmon. However, this do suggest together with the common price development that the same factors that has led to productivity growth for aquaculture in general and salmon in particular (Asche, 2008; Kumar and Engle, 2016; Anderson et al., 2019) also have impacted salmon trout.

[5] There is a rapidly increasing literature on sustainable seafood indicating that producers with production labeled to be sustainable obtains a price premium that has an increasing impact also on aquaculture (Roheim et al., 2018; Osmundsen et al., 2020). Alfnes et al. (2018) indicates that there are 48 different sustainability labels in use for salmon, and Bronnmann and Asche (2017) show that the generally negative consumer perception of farmed fish relatively to wild can be made up with an ecolabel. However, salmon trout has received little attention in the respect, and this does not seem to be a potential explanation for the limited premium. Asche et al. (2015) and Ankamah-Yeboah et al. (2016) show that there a significant premium associated with organic labeled salmon, a fish that is significantly more expensive to produce, suggesting that the moderate premium may be associated with higher production costs.

[6] This also implies that the Fishpool exchange (Asche, Misund and Oglend, 2016; Misund and Asche, 2016; Ankamah-Yeboah et al., 2017) can be used equally well for salmon trout as for salmon. It is also worthwhile to note that while fish price volatility in general is high (Dahl and Oglend, 2014; Asche, Dahl and Steen, 2015), salmon and thereby by implication salmon trout are among the less volatile fish prices. A consequence is also that salmon trout production has most likely been as profitable on a per unit basis as salmon (Misund and Nygård, 2018).

Table 1. Summary statistics export prices: Jan 2000-Dec 2018

	Mean	Std. Dev.	Min	Max	CV
Salmon trout, fresh whole	35.91	13.48	15.91	76.16	0.38
Salmon trout, frozen whole	35.99	12.60	17.12	78.86	0.35
Atlantic salmon, fresh whole	35.38	13.12	17.47	73.17	0.37

Figure 4 also indicates that there is no clear seasonality in the prices, a feature that is well known for the salmon price (Asche and Guttormsen, 2001), even though there is seasonality in production cost (Asche, Oglend and Kleppe, 2017). There is seasonality in the harvesting (Asche, Oglend and Zhang, 2015), a feature which is largely demand driven with a clear peak around Christmas, but as it is expected, it does not show up in the prices.[7] The seasonality in the exports is very similar for fresh salmon trout to what is the case for fresh salmon. The seasonal pattern is stronger for frozen salmon trout, this also aligns with what one can observe for frozen salmon, and shows that the storable product follows the cycle in production cost more closely. The fact that the seasonal patterns for salmon trout does not deviate to any extent from Atlantic salmon indicates that this is not a margin where there is additional premiums or cost for salmon trout.

3.2 Market integration

[7] The seasonality is still moderate compared to what is the case in most fisheries as descrbed in the case of Norwegian fisheries by e.g. Bertheussen and Dreyer (2019) and Birkenback et al. (2020).

The basic relationship to be investigate in a market integration study is (Asche, Bremnes and Wessells, 1999):

$$lnP_{1,t} = \hat{\alpha} + \hat{\beta} lnP_{2,t} + e_t, \qquad (1)$$

where $P_{1,t}$ and $P_{2,t}$ are the prices of two different goods at time *t* The parameter α is a constant term that captures transportation cost and/or quality differences. Other factors that influence price are assumed random with expectation zero and are captured in the error term, e_t. The main interest is related to the parameter $\hat{\beta}$. Perfect or full market integration implies that $\hat{\beta} = 1$, so that the two prices moves proportionally over time. This is often labeled as the Law of One Price (LOP). On the other hand, if $\hat{\beta} = 0$ there is no relationship between the prices and the price determination process for the two products are independent. If $0 < \hat{\beta} < 1$ there is a relationship between the prices indicating that the two prices influence each other, but not completely. Hence there is market integration, but this is incomplete or alternatively, the two products are imperfect substitutes.

OLS regression requires that the probability distribution of each variable in the regression remain stationary over time, which can be translated into requirements of a constant mean, variance, and covariance. Since most price variables in economics are nonstationary in levels, estimating equations without any transformation or augmentation is not advisable. Taking the first-difference of the price variables will often lead to stationarity. Several tests can be used to evaluate if a series is nonstationary but the augmented Dickey-Fuller (ADF) test and generalized least squares Dickey-Fuller (glsDF) tests are commonly used (Elliott et al., 1996; Gordon, 1995). The ADF is a test of the null hypothesis that the price series is stationary in first-differences with the alternative hypothesis stationary in levels. The glsDF differs from the traditional DF test by a transformation based on a generalized least squares procedure before the DF test. A distinction between the two tests is that the glsDF has more power to detect near stationary series.

Even if non-stationarity price series violates distributional conditions of traditional regression analysis, one can still estimate equation (1) if the relationship between the two prices can be modelled in a way that makes the error term stationary; in this case, the prices are said to be cointegrated meaning they form a long-run relationship. Engle and Granger (1987) suggested to estimate equation (1) using OLS and test the predicted model if the resulting errors were stationary. However, this procedure ignores the endogeneity issues that characterizes many cointegration relationships, namely, that influence between prices go both ways. An approach that avoids the endogeneity issue is the Johansen cointegration procedure (Johansen 1988, 1991). This procedure uses a vector autoregressive estimation framework where all the included variables initially are treated as endogenous. Moreover, this framework allows hypothesis testing such as if the LOP holds, or if any of the price variables are weakly exogenous. As noted above, a test for the LOP entails a test of the null hypothesis that $\hat{\beta} = 1$. The exogeneity tests is a test of whether a variable is determined outside the system in question, and therefore if it leads the other prices.

Another advantage of the Johansen procedure is that it can handle a multivariate system of non-stationary variables (Johansen, 1988). Testing cointegrating relationships are therefore not constrained to bivariate cases as described by equation 1. The estimated equations contain both the long-run parameters that correspond to equation 1 (i.e., cointegration) and short-run parameters that can be interpreted as the speed of adjustment to the long-run equilibrium relationship. In a multivariate market integration setting, all prices must share the same stochastic trend to have a common price determination process. In a system with n prices, this implies the existence of n-1 cointegration vectors (Asche, Bremnes and Wessells, 1999).

In the Johansen framework, test of co-integration in the Johansen framework, the max test and the trace test, are based on the eigenvalues of the maximum-likelihood estimation (Johansen and Juselius, 1991). The two tests have the null hypothesis that there are a maximum k cointegration vectors. They differ in the alternative hypothesis, where the max tests for more than k cointegration vectors, while the trace tests if there are $k + 1$ cointegration vectors.

4. Empirical results

The first step in the analysis is to determine the time series properties of the price series. In particular, one is interested in testing whether the series are stationary or not. For the log of the levels of the three prices series, the null hypothesis of a unit root is not rejected for neither the more conventional ADF test or for the glsDF test, which has more power to reject the null. However, the null of a unit root is firmly rejected for all the three prices after they have been differenced, in the column to the far right in the table. This suggest that all the prices are nonstationary and containing one unit root, which makes the cointegration procedure appropriate for analyzing market integration. This is not surprising as this is what is commonly reported for salmon prices (Tveteras and Asche, 2008: Nielsen et al, 201; Asche et al., 2014; Landazuri-Tveteras et al., 2018).

Table 2. Stationary; Dickey-Fuller and Generalized Least Squares Dickey-Fuller

	ADF *log levels*	glsDF[a] *log levels*	glsDF[b] *log first diff.*
Salmon trout, fresh whole	-3.09	-2.17	-9.51**
Salmon trout, frozen whole	-2.96	-1.85	-7.77**
Atlantic salmon, fresh whole	-2.99	-2.54	-9.10**

** indicate statistical significance at the 1 percent level and * at the 5 percent level.
[a] glsDF test statistic in levels
[b] Null hypothesis is stationary in second-differences with an alternative of stationary in first-differences, glsDF test statistic

Given that the prices are first difference stationary, the next step is to analyze whether there exists cointegrating relationships between the series. It is common to start with bivariate tests of cointegration. Since there are three price series that makes it sufficient to run two bivariate cointegration tests where the fresh salmon price is used in both. These are reported in Table 3 together with tests of the LOP hypothesis and of weak exogeneity.

The first test is the relationship between fresh fresh whole salmon trout and fresh whole salmon. Both the trace and max test reject that null hypothesis that there are zero cointegrating vectors. Moreover, the trace test does not reject the null of one cointegrating vector, while the max test keep the null that there are at least one cointegrating vector. This supports that the relationship between the two prices is stationary and, consequently, that they are cointegrated sharing the same stochastic trend. The test of the LOP give further evidence of strong market integration, as the null of fully integrated markets (i.e., that $\hat{\beta} = 1$ in equation 1) cannot rejected. The test of weak exogeneity is rejected for the fresh whole trout price at the 5 percent level, but not for fresh whole salmon. Hence, Atlantic salmon is the price leader in this relationship.

The bivariate test between frozen trout and fresh salmon mirrors the results from that between fresh trout and fresh salmon; the trace and max tests suggest there is one cointegrating vector and the LOP hypothesis cannot be rejected and again, the tests of weak exogeneity suggests salmon is the price leader.

While the market integration relationships are not influenced by the tests only being bivariate, the weak exogenity can be influenced. A multivariate test with all three prices is therefore also conducted and reported in the last three rows of Table 3. The results confirm the findings as the cointegration tests show evidence of two cointegrating vectors. The tests of weak exogeneity indicate that the prices of fresh and frozen trout are endogenous in the system, while the salmon price is weakly exogenous. In other words, salmon is the price leader and the LOP cannot be rejected. Hence, salmon trout is well integrated into the salmon market, and there is no evidence of differentiation. The results are similar to what has been found for wild salmon in relation to farmed Atlantic

Table 3. Bivariate and trivariate cointegration tests between fresh whole salmon trout, frozen whole salmon trout, and fresh Atlantic salmon†

Export price of fresh whole salmon with trout prices:	*H0: rank =P*	*# Lags*	*Trace Test*	*Max Test*	*Law of One Price*	*Weak Exogeneity*
Whole fresh trout	$k = 0$	1	19.15 *	18.20**	0.05	5.25*
Fresh Atlantic salmon	$k \leq 1$		0.95	2.14		3.51
Whole frozen trout	$k = 0$	2	20.62**	20.07**	0.01	14.22**
Fresh Atlantic salmon	$k \leq 1$		0.85	0.82		2.49
Whole fresh trout	$k = 0$	3	71.00**	50.86**	3.95	9.21*
Whole frozen trout	$k \leq 1$		20.14**	17.80**		25.91**
Fresh Atlantic salmon	$k \leq 2$		2.34	2.34		4.39

** indicate statistical significance at the 1 percent level and * at the 5 percent level.

† In all three VAR systems, the tests of autocorrelation, normality, and heterogeneity kept the null hypotheses indicating that the models were well specified. This was achieved by including dummies to account for outlier residuals defined as more than three standard deviations from the mean. The number of included dummies in the three VAR systems ranged from 1 to 4. The dummies, each representing singular months, were included as unrestricted (i.e., not part of the cointegrating long-run relationship).

salmon (Asche, Bremnes and Wessels, 1999) and Chilean salmon in relation to Norwegian salmon (Asche, Cojocaru and Sikveland, 2018) in that the market is highly integrated, and the price of Norwegian Atlantic salmon lead the market.

4.1 Targeting specific markets

The red color of the salmon trout flesh is an attribute that was important in the 1990s. The expansion in the Norwegian production (and also the Chilean one) corresponds to a period when farmed salmon largely took over the Japanese salmon market from wild salmon from Alaska (Tveteras and Asche, 2008). In year 2000 as much as 95.4% of the Norwegian salmon trout exports was whole frozen. Most of it was shipped to Japan, although Russia had started to become an important market in the late 1990s.

In Figure 5, the Norwegian exports of the three most important product forms of salmon trout is shown. As one can see, two product forms dominate, the third is fresh fillets and never has an export share higher than 5.5%. The most notable feature is the significant shift in export share from whole frozen which dominated in 2000 towards whole fresh. By 2018 whole fresh is by far the most important with an export share of 73.4%, while the share for whole frozen is down to 22%. Initially, this shift was incentivized by increased demand from Russia, where there in some setting also where a strong preference for red fleshed salmon. An import stop to Russia for a period in 2006 is clearly visible as a shift back to frozen as exporters was scrambling to find new markets, and although the exports to Russia of fresh recovered somewhat, they completely stopped with the trade embargos following the Russian invasion of Crimea in 2014. The fresh salmon trout was in the 2010s largely diverted to the EU, which now constitutes the main market. As this is the main market also for the Norwegian Atlantic salmon, the red flesh and the market opportunities it provided in first Japan and then Russia was important for the production expansion in the 1990s and possibly the early 2000s, but it has little relevance now. Hence, there do not appear to be specific product attributes that gives the salmon trout any advantage in any specific markets any longer.

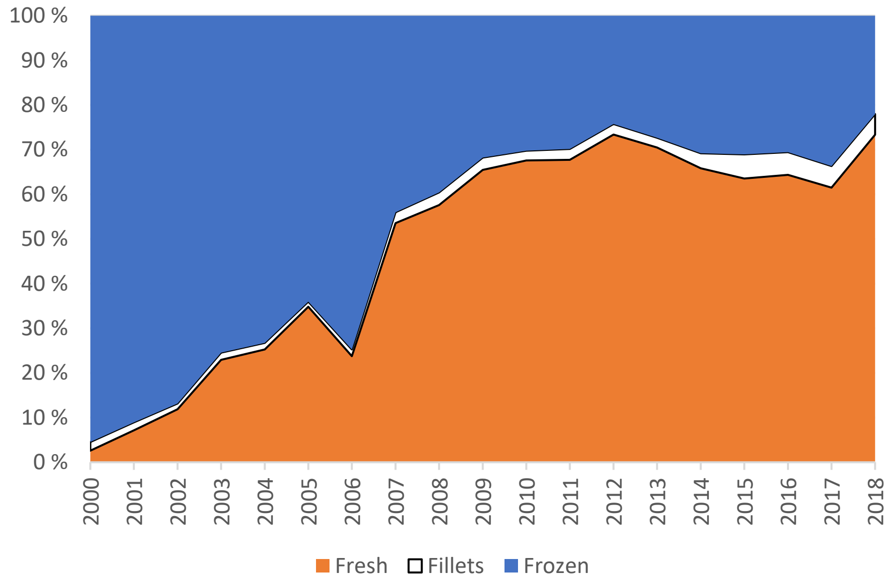

Figure 5. Export shares by product form for salmon trout

5. Concluding remarks

The two largest producing countries of salmon, Norway and Chile, both maintain a significant production of a second species, salmon trout. This paper has investigated potential reasons for this segmentation in Norway, and the conclusion is largely negative in that there appear to be no apparent market reasons. Currently, salmon trout is well-integrated into the lager salmon market, with the LOP holding and the price of Atlantic salmon determining the price for salmon trout. Price volatility is similar, as are seasonal patterns. The redder flesh appears to be the main reason why production of salmon trout increased rapidly in the 1990s primarily targeting the Japanese market. However, with a weaker Japanese market, most salmon trout now go to the main market for Atlantic salmon, the EU, and there do not appear to be any markets with a clear preference for the redder fleshed fish.

There is a small price premium for salmon trout relatively to Atlantic salmon, but this does not appear to cover additional cost as the production of salmon trout has been relatively stable although with significant between year variation since the turn of the millennium while the production of Atlantic salmon has been rapidly increasing. Hence, most farmers appear to prefer Atlantic salmon. However, the disadvantage with producing salmon trout does not appear to be large, given that the production level is maintained even in this environment.

With no clear economic reasons for why farmers are producing salmon trout, it is likely to maintain a precarious position. Production was going down in the late 1980s until the Japanese preference for red-fleshed salmon opened that market. That is a pattern that may well be repeated if one cannot find new market segments with a clear preference for salmon trout. This is a risk that may be exacerbated by new production technologies in salmon aquaculture such as land-based farming (Bjørndal and Tusvik, 2019), which does not seem to be applied to production of salmon trout. On the other hand, disease risk appears to be an increasingly important factor in salmon production. Oglend and Tveteras (2009) argue that geographical diversification is a potential tool. Species diversification can be another, and that may give salmon trout a role also in the future.

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Buy the good wine: Duration of Norwegian Wine Imports

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Buy the good wine: Duration of Norwegian Wine Imports

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Abstract:

As for all traded products, aggregated wine imports build on numerous trades at the firm level. To ensure consumers access to a variety of wines with different qualities, importers need to connect to different wine exporters. Some of these relationships will last for a long time, while others may rapidly cease to exist. In this paper, we employ transaction level data to analyse the duration of trade relationships in wine imports to Norway from 2004 to 2014. We find that most relationships are short-lived, as more than 75% of trade relationships end after less than two years. Furthermore, we find that higher quality wines, as indicated by the import price, increases trade duration. Deeper firm-to-firm trade relationships for more exclusive wines is likely due to higher search costs for high quality products. The results also show that the size of the initial trade between the partners, or degree of commitment, is a positive determinant for persistent relationships.

Keywords: wine, duration of trade, transaction data

JEL classification: C41, F14, Q27

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1. Introduction

Globalization have strongly influenced international wine markets during the recent decades, resulting in a rapid growth in trade (Campbell & Guibert, 2006), and structural shifts in trade patterns (Anderson & Wittwer, 2013; Angela Mariani, Pomarici, & Boatto, 2012). This is partly due to the introduction of new wine producing countries, and partly due to new destination markets for exports, with a particular emphasis on China. Recent studies on trade patterns for wine investigates the role of factors such as exchange rates, regulations, trade barriers and development of new markets on trade (Dal Bianco, Boatto, Caracciolo, & Santeramo, 2015; A Mariani, Napoletano, Pomarici, & Vecchio, 2014).

However, besides noting that keener competition in the global marketplace have made relationships between buyers and sellers of wine more fickle (Balogh & Jámbor, 2017), duration of wine trade relationships has received limited attention. The ability of a firm to maintain established trading-partner relationships over time reduces market-specific search and investment costs at the firm-level, and is thus important for the trade cost for firms (Melitz, 2003), and this is true also for the trade in wine. For wine products, the fact that specific *terroirs* are necessary for many qualities, may also cause trade duration patterns to deviate from what is observed for other products, as suppliers may have a stronger position due to the uniqueness of their products, particularly for high quality wine.

Trade duration is an important part of firms trade margins, and was first investigated by Besedeš and Prusa (2006a, 2006b) using country-to-country level data. They showed that trade relationships in US imports for all types of products are highly dynamic with a mean survival rate between 2-4 years. Such short durations are much more volatile than what is predicted by standard trade theory. In recent years, there has been an increasing focus on the role of firms in international trade, with a particular focus on trade cost. The seminal model of Melitz (2003) showed that trade costs can vary between firms and markets and contain fixed, as well as variable components, influencing which firms export to any specific market. Esteve-Pérez, Requena-Silvente, and Pallardó-Lopez (2013) use firm data to study duration and shows that trade patterns are more dynamic at the firm level than on the country level.

In this paper, we investigate the duration of trade relationships for wine imports to Norway. The fact that no wine is produced in Norway has two advantages: 1) the trade data completely characterizes the market and 2) there are no discriminatory fees or tariffs for any group of producers. The data contains all transactions for firms that imports wine to Norway, linking all the individual transactions to a specific importing and exporting firm. This level of detail in the data allows us to analyse factors that affects the duration of the individual exporter-importer trade relationship. To our knowledge, this paper is the first to study the duration of such highly disaggregated buyer-seller relationships in wine trade.

The next section provides more background on the determinants of the duration of trade and links this discussion to the international wine industry. In section 3, the empirical strategy is described. Section 4 presents the data, followed by section 5 where the empirical results are discussed. Section 6 concludes.

2. Background

Several theoretical models of trade (e.g. Krugman, 1979; Rauch, 1999), shows that trade in differentiated goods, such as wine, is anticipated to last longer than trade in homogeneous goods. Besedeš and Prusa (2006b) and Nitsch (2009) confirms the fact that trade in homogeneous products will have shorter durations than trade in more differentiated products. This paper does not compare trade duration across different types of goods, but rather different 'versions' of a particular good. Specifically, it investigates what role differentiation through quality, as signalled by unit values of wine has on trade duration. In particular, one would expect premium wines to behave more like differentiated products due to unique *terroirs*, while cheaper wines may be more commoditized.

The variation in attributes make wine a differentiated product. One can argue that higher quality wines are more differentiated than lower quality wines, as they are more complex in terms of smells and flavours. Wine prices will to some extent reflect quality, but also embed other attributes such as reputational effects that can be based on past quality and achievements (Oczkowski, 2001; Oczkowski & Doucouliagos, 2014). Wine importers have to look beyond the price to fully understand the type of product, its quality and market potential. This implies that search cost are larger for high-quality wines than for lower-quality bulk wines because importers need to obtain more information for trade in high-quality wines.

The literature on trade duration also shed light on other factors that influence duration. For instance, the initial size of the trade flows is positively linked to duration irrespective of type of good (Besedeš & Prusa, 2006b; Esteve-Pérez et al., 2013). This can be explained by sunk cost and option theory as well as learning models (Caves, 1998, 2007). Firms start with large initial trades when they commit to the trade relationship, which then give them the option to grow the trade even larger when confirming their initial belief in the trading partnership.

Size of producers matters in terms of participation in wine exports. Larger firms will have a greater propensity to export (Aylward, 2003), but size does not appear to be a prerequisite to participate as both small and large firms participate (Aylward, 2003; Suarez-Ortega, 2003). One explanation for this might be constant returns-to-scale, making the cost advantage of large exporters less obvious (Townsend, Kirsten, & Vink, 1998). Nonetheless, among small and medium large producers, Maurel (2009) find the largest firms have the highest export performance as measured by export intensity.

Ambiguous results about the link between size and export performance can also be related to quality, rather than productivity, as shown in Crozet et al. (2011). Their study analyses the champagne market and find that better quality increases the propensity to export and that price rises monotonically with quality. However, in markets for other wine types reputation appears to be equally important determinant of price (María Angulo, María Gil, Gracia, & Sánchez, 2000; Oczkowski, 2001; Oczkowski & Doucouliagos, 2014). These differing results about price-quality relationship can exist due to different ways of measuring quality and, as Combris, Lecocq, and Visser (1997) discuss, because the judgment of experts might not conform to the taste preferences of wine consumers in general. In any case, the price-quality relationship appears to be reasonably strong as one can assume that reputation is partly based on past quality performance.

Trade duration models often incorporates elements of the gravity model of trade, as standard gravity variables are known to influence trade flows, and thus also potentially duration of trade relations. Nitsch (2009) and Esteve-Perez et al. (2013), Straume (2017) and Asche et al. (2018) shows that trade duration are negatively affected by increased geographical distance to the destination market, while the results are mixerd with respect to the economic size of the destination market. Dal Bianco et al. (2015) find that distance have a negative influence on trade flows of wine using a gravity model specifications that include distance as a standard variable to explain the effect from increased transportation costs on trade values.

In other studies of international wine trade geographical distance is seldom discussed as an issue (Anderson & Wittwer, 2013; Angela Mariani et al., 2012). Instead, trade barriers in terms of restrictions or additional taxes on wine imports have received attention as an influence om international trade (Dal Bianco et al., 2015; A Mariani et al., 2014; Wiseman & Ellig, 2007). These studies show that trade barriers have a negative impact on wine exports to different markets. In our analysis, all agents in the market are subject to the same import regulations so these cross-country differences in regulations and taxation do not come into play.

Changing patterns in trade can be driven by different factors that influence the relative competitiveness of different producer countries (Hussain, Cholette, & Castaldi, 2008). One key factor that influence price competitiveness in wine trade is exchange rates. For example, Anderson and Wittwer (2013) find that changes in the real exchange rate can to a great extent explain why New World producers such as Australia and Southern World producers lost market shares in a period from 2007 to 2011. During this period, Australia experienced an appreciation in the real exchange rate of 33% that led to a reduction of its wine exports.

Characteristics of the Norwegian wine market may also influence trade duration. For example, the growth in wine consumption in Norway, which has increased from around 27 thousand litres per year in the early 1990s to around 76 thousand litres per year in 2013 after which it has levelled off, might have influenced trade duration positively. A similar trend is noted in per capita wine consumption, which was just under 8 liters per year in the early nineties, and increased to around 18.5 liters per year in the 2010s.

A particular characteristic of the Norwegian wine market is that all retail sales of beverages with alcohol content above 4.75% has to be conducted by the state-run Wine Monopoly stores (Vinmonopolet). The monopoly was introduced by the Norwegian government as a means to control alcohol consumption and, thus, negative effects of alcohol consumption on society. One of the key regulations to reduce consumption is a high tax on alcohol. As Casini, Corsi, Rickertsen, Lai, and Cavicchi (2013) note: "*High tax rates per unit of alcohol [in Norway] mean that cheap wines become relatively expensive, while expensive wines become relatively cheap. In other words, high-quality wines have more or less the same price as identical wines purchased abroad, while cheap wines are much more expensive than abroad*." An effect of this policy is to dampen the quality signal of wine prices.

Although the Wine Monopoly has exclusive retailing rights, the rights to import wines was deregulated in 1995. Since then the number of private importers has grown steadily. In 2004, there were 125 importers that provided wines to the monopoly, while in 2014 this number had increased to 404 importers (Wine Monopoly, 2004, 2014). This means that wine distribution in Norway can be viewed as a public-private partnership. There is a large selection of wines in Norway with more than 8,000 wines available from the main wine-producing countries (Casini et al., 2013). The most-selling wines are available in all of the Wine Monopoly's outlets, while those not stocked in an outlet can be ordered without additional charges.

According to an in-depth article from Dagens Næringsliv, a Norwegian business newspaper, the competitive climate among Norwegian wine importers hardened substantially over the data period with the increased number of importers (Kristiansen, 2016). A sign of these new times was signalled by incumbent importers accusing new firms of 'stealing' wine brands. Supposedly, this was done by slandering about incumbents lack of sales and promotion in Norway to wine exporters/producers and by other methods perceived as unfair by the incumbents. Structural changes in the competition among the importing firms may therefore also have influenced duration of trade relationships.

3. Empirical strategy

To estimate the duration of trade relations we apply survival analysis. Survival analysis estimates the expected duration of time before some event terminates a relationship. In the health sector this can be the death of a patient. In economics, it is typically related to firms going out of business or the termination of trading partner relationships. In general, the survival function can be specified as

(1) $f(t) = h(t)S(t)$

where $f(t)$ is the probability density function of T (i.e., the probability of failure at time t), $S(t)$ is the survival function that gives the probability that an observation survives longer than t. In other words, the survival function is the probability that there is no failure prior to time t. The Kaplan-Meier nonparametric estimator is a common technique to graph the shape of the survival function.

Finally, $h(t)$ is the hazard function which gives the rate of failure at a time t, given that the unit of observation has survived up to time t. That the hazard function $h(t)$ is a ratio can be seen more easily by rewriting equation (1) as $h(t) = f(t)/S(t)$. The hazard rate can vary from zero (meaning no risk of failure at all) to infinity (certain failure). It can be shown that the hazard rate can be reformulated as a regression of the form (Greene, 2003):

(2) $$h(t|X) = h(t)exp(X\beta),$$

where the hazard rate is conditional on a set of covariates, *X*. In the trade literature the hazard rate is usually estimated using a Cox proportional hazards model (Besedes and Prusa, 2006a; Nitsch, 2009). Even if the baseline hazard $h(t)$ is not specified, the Cox model's results will closely approximate the results for the correct parametric model. Another advantage is that one can obtain the estimated betas, representing the true βs (i.e., the parametric part of the Cox function), without having parameterized the hazard function (i.e., the non-parametric part of the Cox function). The latter also implies that no assumptions about the underlying distribution of the hazard function is required. Some trade relationships can experience multiple failures, meaning that trades are disrupted between an exporter-importer firm pair to be resumed later on.

4. Data

The data used in this paper is taken from customs records identifying each single import transaction of wine from 2004 to 2014 of HS code 22042109.[8] This means that the individual importers and exporters

[8] Other wine of fresh grapes, incl. fortified wines, in bottles with "mushrooms" stoppers held in place by ties or fastenings, holding <= 2 l; wine otherwise put up with an excess

linked to each trade are matched, and the records identify total volume, total statistical value (in NOK), invoicing currency, wine production country, and shipping country associated with the trade. For the analysis left-censored groups were dropped from the data set. This reduced the number of total observations by around 12% leaving a total of 29,666 observations for the analysis.

French (30%), Italian (29%), Spanish (13%) and German (7%) wines accounted for around 80% of the total import value during the entire period (see figure 1). This implies that "old world" wine producers clearly dominate the Norwegian market. The four largest countries of origin have actually increased their dominance from 70% in 2004 to 83% in 2014, with Italy's market share growing the most from 20% to 36%.

pressure due to carbon dioxide in solution of >= 1 bar but < 3 bar measured at 20°C, in containers holding <= 2 l (excl. sparkling wine and varietal wines)

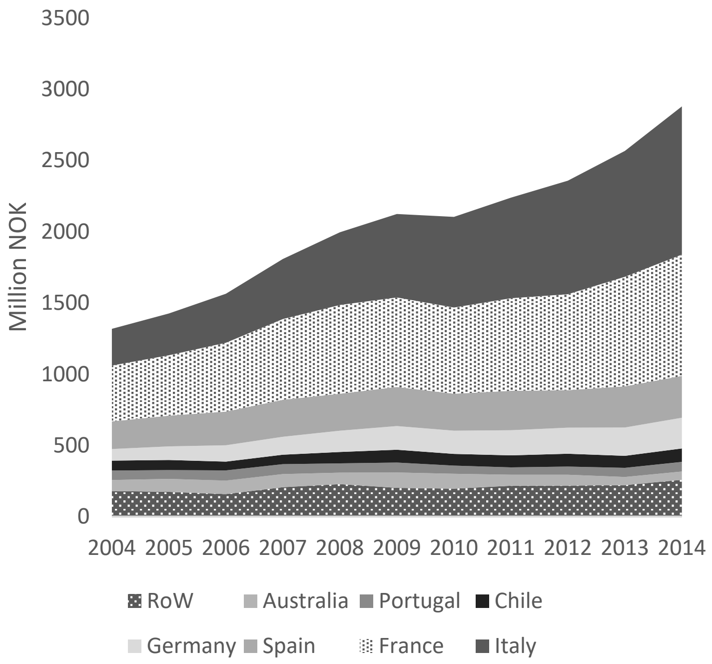

Figure 1. Wine imports to Norway by producing country

The duration analysis is conducted at the firm-to-firm level for a particular wine producing country. Due to this definition of a trade relationship, the same importer and exporter may share more than one trade relationship since a particular exporter may export wines from more than one country. That is, if firm A export wines from France and Italy handled by importing firm B in Norway, this constitute two distinct trade relationships according to our definition. This distinction between wine-producing countries makes it more clean-cut to identify effects of exchange rates and GDP on trade relationships. Moreover, it makes sense since the trade from two distinct countries will represent different quality wines and generally different wine producers.

The number of importers and the average volume they import are shown in Figure 2. The number of importers increased steadily until the financial crisis started in 2008 after which many appears to have exited. Then in 2011, the number started to increase again, but never exceeded the peak in 2008. Another noteworthy pattern in the graph is that the average imported volume per firm was at its lowest in 2008, and since 2009, it has been on a higher level compared to the pre-financial crisis years. However, it is important to keep in mind that wine consumption in Norway has increased throughout the data period. This may help to explain why average volume per importer has been increasing. We now turn to look at key statistics of the variables in the data set.

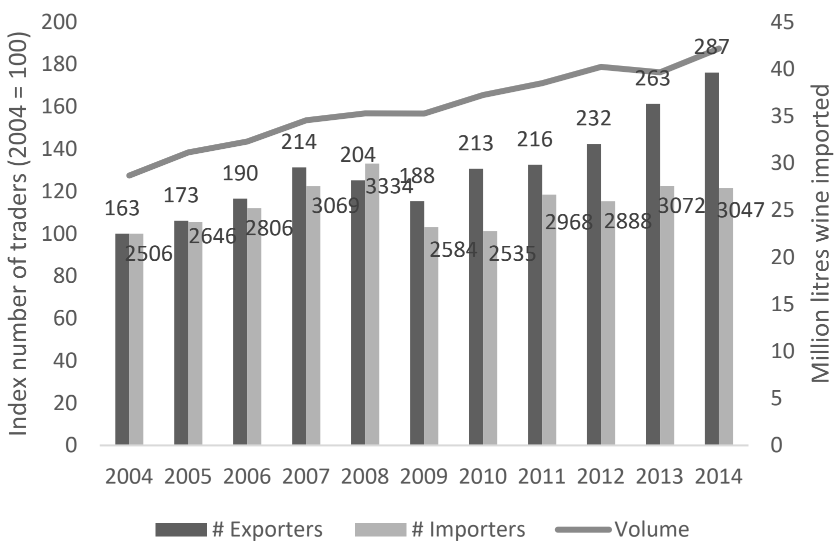

Figure 2. Number of wine importers and exporters and annual imported volume of wine.

Table 1 shows descriptive statistics of the variables. The *Distance* variable measure between wine exporter and Norway were obtained from distancefromto.net. This web engine uses Google Maps to calculate distances between two geographical points. *GDP exporter* is used to measure the size of the exporting countries' economies. The exporters' GDP are denoted in fixed prices of local currency and were collected from the World Bank. *Exchange rate* measures the wine importer's currency, Norwegian kroner (NOK), against the exporters' currencies. A rise in *Exchange rate* implies the import of that country's wine becomes relatively more expensive compared to other countries' wines that use different currencies. The source of the exchange rate data is the central bank of Norway.

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Distance	29,666	3,128	3,570	472.3	17,668
GDP exporter (million LCU)	29,666	4.283	16.400	1.676	140.500
Exchange rate	28,890	0.151	0.156	0.085	1.723
Unit value	29,666	20.04	68.35	0	3,572
Initial quantity	29,666	6,514	28,448	1	1008000
# Importing firms	29,666	99.24	42.86	8	187
# Exporting firms	29,666	740.9	458.6	10	1,370
Importer-exporter ratio	29,666	0.217	0.152	0.077	0.960
Multiple spells	29,666	0.0637	0.244	0	1
Samecountry	29,666	0.944	0.229	0	1
Overseas	29,666	0.124	0.329	0	1

Crozet et al. (2011) found that quality is a far more important predictor of export success among champagne producers than productivity. Unlike Crozet et al. (2011) we do not have a direct measure of quality, but use unit value of imports as a proxy for quality. Price has been found to be a good, but imperfect, measure of quality (Combris et al., 1997; María Angulo et al., 2000). For instance, Oczkowski (2001) found that for Australian wines reputation was a stronger predictor of prices than quality. But reputation is likely linked to past quality of wine, which still means there is a strong quality-price relationship (Landon & Smith, 1997; Oczkowski & Doucouliagos, 2014).

Unit value measures the average price per litre per shipment denoted in NOK. The mean price is 107 NOK per litre imported wine, which corresponds to slightly above 13 USD per litre. As can be expected there is large span between minimum and maximum values given the significant quality differences for wine. The standard deviation of import prices is around 24 USD per litre.

Initial quantity measures the size of the first shipment in every exporter-importer-trade relationship. The main purpose of this variable is to capture scale effects on trade duration. Larger initial quantity are normally associated with longer duration of trade relationships (Besedeš & Prusa, 2006b). Another factor that can influence survival rate is the number of firms in the market. For example, it was discussed earlier that the competitive environment among Norwegian wine importers appears to have changed towards a more cut-throat competition (Kristiansen, 2016). To capture such changes we include # *Importing firms*, which measures the yearly number of how many Norwegian firms that import wines from the individual wine-producing countries.

Note that this measures contrasts the total number of importers shown in Figure 2, since the variable *# Importing firms* only counts the number of firms importing from a particular wine-producing country, say, from France. The idea is that an importer-exporter relationship of French wines is influenced by the total number of Norwegian importers targeting French wine producers and not the number of wine-importing firms operating in Norway altogether. This can be a reasonable delineation if Norwegian importers must commit large investments when moving from one wine-producing country to another.

Similarly, the variable *# Exporting firms* measures how many firms per year exports wine to Norway from a specific wine-producing country. We also include an alternative measure to capture potential competition effects generated by the number of market players, which is the ratio of importers over exporters, denoted *Importer-exporter-ratio*.

The final five variables are dummy variables, so that the mean value shows the share of instances where these variables take the value 1. *Multiple spells* capture the number of observations where exporter-importer trade relationships have several spells. *Same country* indicates when the wine is shipped from the same country it is produced. Table 1 shows that almost 95% of the shipments are sent directly form the producing country, so it is quite unusual that a wine is re-exported from another country. *Overseas* is a dummy for wines originating outside of Europe, which is predominantly from Oceania, South Africa, South

America, and USA. These overseas producers account for around 12% of the imported wines. Finally, there is a dummy for the financial crisis and another to capture structural effects of the regulatory changes in 2010 in rules for importing wines to Norway.

Figure 3 shows the Kaplan-Meier estimates of the survival rates for the trade relations from year-to-year. More than 60 % of the established relations trade together for only one year, and more than 75% of the relations end after two years. Hardly any trade relationships survive the entire sample period of ten years. There appears to be little variation in this survival pattern if we break down the data sample on the source country of imported wines, at least not among the large wine producers. Hence, the general pattern of short-lived trading relationships is common across wine-producing regions.

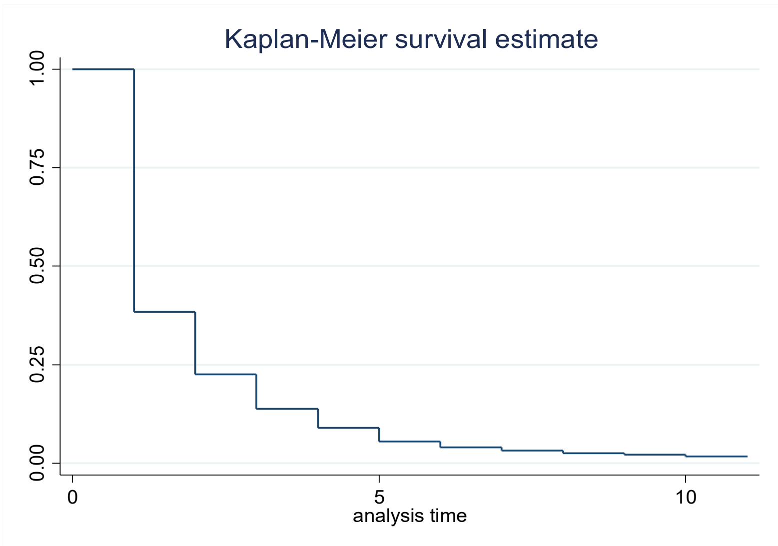

Figure 3. Survival rate of trading partners from year-to-year

5. Empirical results

The results from the Cox proportional hazard models are reported in Table 2. The estimated coefficients from the Cox-model are interpreted differently form OLS-estimates. Coefficients that are larger than one scale up the hazard ratio, while coefficients lower than one scales it down and coefficients that equals one do not influence the hazard ratio. The difference between Model 1 and 2 is how the number of buyers and sellers are modelled; in model 1 the number of importers and exporters are included as two separate variables, while in model 2 they are included as a ratio (i.e., number of importers divided by the number of exporters). The magnitude of the estimated parameters of the other variables remain similar in the two models. An estimated hazard rate with a value below one indicates that an increase in the corresponding variable decreases the probability for failure in the trade relationship, while a value larger than one indicates increased probability for failure.

The first covariate reported in Model 1 is the geographical distance to the wine producing countries. The *Distance* coefficient is slightly higher than one but statistically insignificant indicating that distance does not influence duration. It is significant in model 2, indicating that distance reduce duration slightly, but as the magnitude is close to 1 transaction costs associated with distance have little impact on the duration of wine trade. From the trade literature, we know that trade in perishable products are most sensitive to the geographical distance between markets.

Table 2. The Cox proportional hazard model

	Model 1	Model 2
ln Distance	1.036	1.045*
	(0.024)	(0.024)
ln GDP exporter	1.006	1.004
	(0.009)	(0.009)
ln Exchange rate	0.931***	0.930***
	(0.014)	(0.014)
ln Unit value	0.937***	0.937***
	(0.007)	(0.007)
ln Inital quantity	0.901***	0.901***
	(0.003)	(0.003)
# Importing firms	1.119**	
	(0.054)	
# Exporting firms	0.949**	
	(0.021)	
Importer-exporter ratio		1.411**
		(0.224)
Multiple spells	1.482***	1.483***
	(0.053)	(0.053)
Samecountry	1.004	1.008
	(0.024)	(0.025)
Overseas	0.898*	0.885**
	(0.055)	(0.054)
Oldworld	0.964	1.009
	(0.037)	(0.029)
Year dummies	Yes	Yes
Observations	28,890	28,890

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exporters' GDP with a coefficient approximately equal to one has no impact on trade duration. Although the exporters GDP could proxy other characteristics of the exporting country relevant for trade duration, it is not that obvious what this should be in this particular context where we analyse flows of a specific product type to a single import market.

The estimated coefficient for *Exchange rate* is lower than one, impling that a weakening of the exporter's currency relative to the importers currency, NOK, increase trade duration. The *unit value* is statistically significant at the one percent level and an increase in the unit value increase the duration of the trading partners' relationship. This indicates that the wine quality is a positive factor for trade duration. The results related to the average wine prices is an extension of the findings in Crozet et al. (2011) who analyzed export propensity. Our results shows that not only trade propensity is affected by wine quality, but also the duration of trade relationships.

Another highly significant factor is *Initial quanitity*. A large first shipment between a specific wine exporter and importer pair increases the probability of a lasting trade relationship between those two partners. A large initial trade may signal commitment. Model 1 shows that while a growth in the number of importers increase the hazard of a breakdown in trade relationships, the number of exporters have the opposite effect. This asymmetric effect could be because wine exporters have several international markets where they can sell their product. In contrast, importers compete for limited shelf space in the Norwegian wine monopoly's retail stores and in Norwegian restaurants, and for importing the best-selling wines to the Norwegian public.

To see if this asymmetry result appears robust, Model 2 reformulates the number of importers and exporters as a ratio, the *Importer-exporter ratio*. The estimated coefficient of this variable supports the results from Model 1 since it suggests that the hazard of a breakdown in trade relationships grows as the ratio of importers per exporter increases. Moreover, this lends support that a tougher competitive climate has influenced trade duration in Norwegian wine imports. This is based on the observation that the number of importers per exporter, on average, have increased for the four largest wine-exporting countries to Norway, as shown in Figure 4.

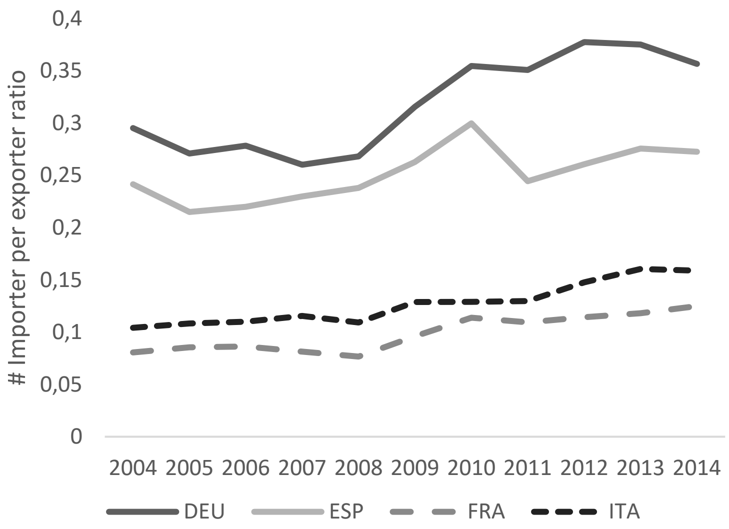

Figure 4. Number of importers per exporters for the four most important wine exporting countries to the Norwegian wine import market

Trade relationships that are associated with multiple spells results in shorter durations. This may indicate that some firms only trade when a producer puts high quality wines on the market, or when the importer does not receive enough supply from his ordinary seller.

The *Same country* dummy is not significant. As it is only in a small fraction of the trade relationships where the exporters actually are located in a different country than the origin-country of the wine this is not very surprising. The *Overseas* variable shows that distant exporters, on average, have longer trade duration with Norwegian importers. This can also be linked to larger specific investments associated with establishing those 'overseas' partnerships (Feenstra & Romalis, 2014). Note that we attempted to remove the *Overseas* dummy as it could be correlated with distance. However, the *Distance* coefficient remained insignificant in Model 1 and the parameter value did not change very much in either model. This may be due to the dominance of the European producers.

6. Conclusion

Global wine trade continues to grow with new agents entering the market (Balogh & Jámbor, 2017). The increased competition and participation in the wine market is bound to influence trade dynamics, including duration of trade relationships. In this paper we have access to highly disaggregated data on wine imports to Norway which allows us to link exporter and importer firms. This high quality data is used to analyse how duration of firm-to-firm trade relationships are affected by different factors in an eleven-year period stretching from 2004 to 2014. The first result from the study is that most trade relationships are very short. This is a result that aligns with previous findings in the literature, both for duration of overall trade between countries, as well as for trade at the product level.

The main focus of this study is how trade duration is influenced by wine quality as reflected by the price (Oczkowski & Doucouliagos, 2014). Wine is a highly differentiated product with a large spectrum of different qualities and tastes. We show that imports of higher priced wines is associated with longer duration of trade relationships. As expected a weakening of the exporters currency contributed to lengthen the duration of trade relationships. A growing share of Norwegian wine imports has come from France, Germany and Italy. Especially Italy's market share has grown sharply from 19% in 2004 to 34% in 2014. This corresponds to a period when for most of the time the long-term trend of Euro has been of weakening relative to the import currency Norwegian kroner. This indicates that the exchange rate has influenced changes in the relative pattern of trade relationship, geographically speaking.

Another important result is that there is an asymmetric effect of the number of importers from the number of exporters. We argue that this result arise because for most wine sellers Norway is just one of several markets where they can export their product, while for Norwegian importers there is a competition for limited number of wines known to sell among Norwegian consumers. The fact that there is a monopoly of retailing wines in Norway makes shelf-space even limited compared to the normal where wine is also retailed in grocery stores, supermarkets and specialized wine retailers. The limited shelf-space available to efficiently market imported wines can further enhance competition among importers. This underlines that the particular market institutions also can influence competition.

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