RESEARCH ARTICLE

Perish or prosper: Trade patterns for highly perishable seafood products

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Abstract

In recent years trade with highly perishable agricultural products like fresh fish, berries, and cut flowers has increased substantially. The perishability of these products appears to challenge conventional wisdom when it comes to food trade, which emphasizes the importance of large shipments to reduce transportation costs. In this paper, gravity models and several margins of trade are estimated for the trade with fresh salmon, a highly perishable product. The results indicate that increased geographical distance have a larger negative effect than what is generally reported in the literature. Most interestingly, the number of exporters and the shipment frequency increase while there is little impact on shipment size when trade increase. Hence, freshness and possibly avoidance of losses by not selling products by the expiration date seem to be emphasized rather than economies of scale in transportation. [EconLit Citations: F14, Q22].

KEYWORDS
gravity model, margins of trade, perishable products, transaction level data

1 | INTRODUCTION

During the last decades trade liberalization, income growth as well as better and cheaper means of transport and logistics have facilitated a global expansion of trade in food and agricultural commodities. Increasingly this trade also includes highly perishable and often seasonal fresh products like fresh fish, berries, and cut flowers. Better transportation technologies and logistics reduce delivery time, and secure delivery of high-quality products to the end user (Behar & Venables, 2011; Coyle et al., 2001). This development has made more distant producers competitive also for perishable goods, such as fresh seafood. However, with improved transportation technology and logistics the conventional wisdom that shipping costs are most disruptive for perishable products and that increased scale obtained with larger shipments is the main tool to address the increasing cost due to longer distances appears to be challenged (Berthelon & Freund, 2008). Several recent studies suggest that the structure of the shipping cost can be important, as there are different types of fixed and variable cost associated with trade that can be important for margins of trade (Hornok & Koren, 2015; Lawless, 2010a; Melitz, 2003). Hornok and Koren (2015) use custom data and provide a finer set of margins of trade than earlier studies, which allows additional insights into the patterns of trade. This can be essential for the understanding of trade patterns for products with particular characteristics such as fresh products. In this paper we will show that this is the case for one of the world's most traded seafood products—fresh salmon.

Geographical distance between two markets is the state-of-the-art proxy for transportation costs in the international trade literature and is a main component of the gravity model. Most gravity studies use annual data at the country level. However, firm-level exports, and the role of firm heterogeneity have received increased attention in recent years. Bernard et al. (2007) and Redding (2011), provide surveys of this literature. As it is firms that trade, this literature gives a more nuanced picture of trade drivers and patterns using gravity type models, and points to a number of margins that are washed out when using more aggregate data (Hornok & Koren, 2015; Lawless, 2010a). Traditionally, the margins of trade are divided into an extensive margin and an intensive margin. At the firm level, the extensive margin of trade relates to a firm's decision whether to enter a foreign market or not. This margin is commonly measured as the number of firms exporting, or as the number of products being exported (Lawless, 2010a).[1] The most common interpretation of the intensive margin of trade is the development of trade values within established trade relationships. Hornok and Koren (2015) decompose the total export value into several intensive margins, such as number of shipments, average shipment size, and unit price and growth along any of these margins will increase export value.

Several of Hornok & Koren, (2015) intensive margins are potentially important to distinguish trade patterns for perishable products relatively to storable bulk products. For instance, one may expect that a higher shipment frequency might be relatively more important for perishable products due to the importance of transport time, while for traditional product shipment size is more important as it reduce transportation cost. In addition, for perishable products only those of high quality, measured by the unit value, will make it to the most distant markets.

The objective of this paper is to shed light on trade patterns of a highly perishable food product; fresh farmed salmon. Production and trade of salmon have increased dramatically during the last decades, from less than 100,000 tons in 1985 to 2.6 million tons in 2019 (FAO, 2019), with Norway (at the northern rim of Europe) and Chile (at the southern end of South America) as the leading producers with about 85% of total production. There are a number of reasons why it is interesting to study trade with fresh salmon in more detail. It is one of the most successful "new" highly traded perishable products in terms of production growth. The industry is also at the forefront when it comes to development of technology, knowledge, and innovation in aquaculture, the world´s fastest growing food production technology (Asche & Smith, 2018; Smith et al., 2010; Tveterås et al., 2012). This is largely due to the control with the production process in aquaculture that has allowed substantial productivity

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[1]At the country-to-country level, the extensive margin captures the number of countries that one exports to, while the intensive margin captures the export value to a specific country.

growth at the farms (Anderson, 2002; Asche et al., 2009; Oglend & Soini, 2020; Rocha-Aponte, 2020; Roll, 2013), in the supply chain (Asche et al., 2018; Kvaløy & Tveterås, 2008; Olson & Criddle, 2008), as well as rapid product development (Asche et al., 2015; Brækkan et al., 2018). Control with the production process has allowed the producers to harvest salmon all year, to target the most valuable markets and improve logistics, to a larger extent than what is possible in most fisheries (Anderson, 2002; Asche, 2008). This has changed the market for salmon substantially from a relatively small market in North America and Japan with frozen and canned product as the main product forms to a large global market with fresh as the leading product form (Asche & Smith, 2018).[2] Straume, et al. (2020) also show that aquaculture products exhibit characteristics that differs from products from fisheries when it comes to trade. Trade in aquaculture products is more influenced by transportation costs and per-shipment costs then more conserved products from wild fisheries, this underlining another important dimension of the supply chain.

The paper is organized as follows: A brief literature review of the Norwegian salmon industry and data is presented in Section 2. Model specifications are discussed in Section 3, before empirical results are reported in Section 4. Section 5 provides concluding remarks.

2 | INDUSTRY AND DATA

Technology development, as highlighted by Behar and Venables (2011), is a key factor in fostering trade as lower transaction costs reduce the importance of geographical distance. Salmon provides a number of examples of innovations in the supply chain organization and sales mechanisms improving logistics and facilitating trade. These include coordination (Gaasland et al., 2020; Kvaløy & Tveterås, 2008; Olson & Criddle, 2008), contracts (Larsen & Asche, 2011; Oglend & Straume, 2019; Straume et al., 2020), futures trading (Asche et al., 2016; Oglend & Straume, 2020; Oglend, 2013), invoicing (Straume, 2014) and trade duration (Asche et al., 2018; Straume, 2017; Wang et al., 2019; Yang et al., 2021). These innovations have helped creating a global market as the two largest salmon-producing countries, Norway and Chile, export salmon to more than 150 countries. Moreover, with more than 90% of the production occurring in four countries, Norway, Chile, Canada, and the United Kingdom, it is largely an export-driven industry with a highly perishable product form, fresh salmon, as the main product.

The empirical analysis will be conducted based on transaction data collected from the salmon exporters' customs declarations for the period 2004-2014, made available by Statistics Norway. The relevant HS-code is 3021411, whole fresh salmon, which with an export share of about 90% is by far the most important product form exported from Norway. For each transaction the dataset identifies the exporting firm and importing country, the weight in kilos, the export value in Norwegian kroner (NOK), the mode of transportation, and the shipment date. The dataset contains 914,743 unique transactions from 274 Norwegian exporters, serving 102 different desti-nation markets.

Norwegian exports of whole fresh salmon have increased from 335,850 metric tons in 2004 to 809,936 metric tons in 2014. With this strong growth, it is not surprising that there are changes in the supply chain. In the left panel of Figure 1 we show active exporters per year. One can observe a declining trend in the number of exporters, and with the increased export volume this means that on average exporting firms have grown in size. An important decision variable for an exporter is the frequency of shipments. The right panel in Figure 1 shows that the annual number of shipments per firm clearly has decreased over the period. This means that the size of each shipment also increases over the years. Hence, even for a perishable product like salmon, there appears to be some economies of scale in transportation.

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[2]This development has also strongly influenced wild salmon fisheries, as farmed salmon is determining wild salmon prices (Asche, et al., 1999; Valderrama & Anderson, 2010), but it has also allowed the creation of highly profitable market niches for some wild product (Jardine et al., 2014) and other salmonids like trout (Landazuri-Tveteras et al., 2021).
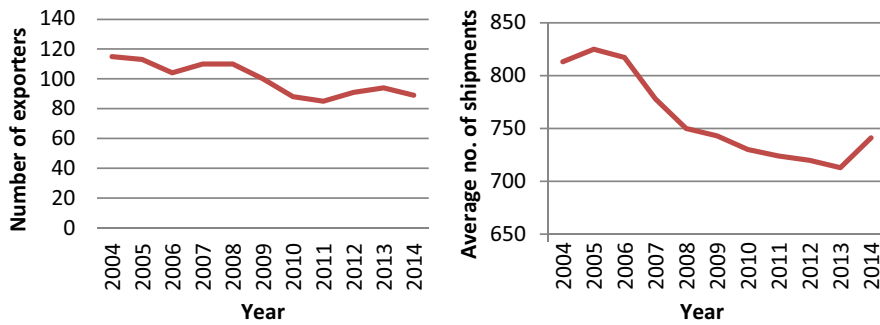
FIGURE 1 Number of exporting firms and the number of shipments per year, 2004–2014. *Source*: Own calculation [Color figure can be viewed at wileyonlinelibrary.com]
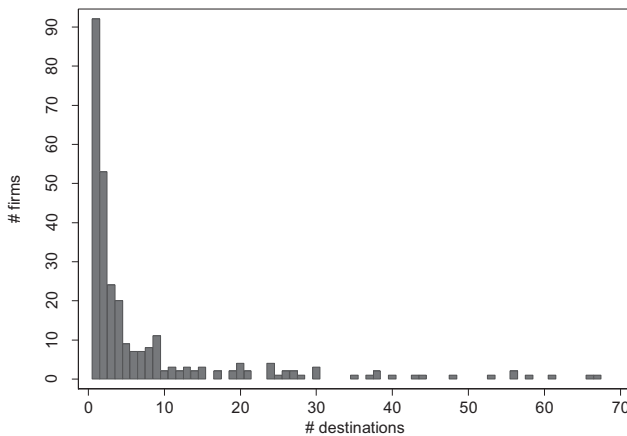

FIGURE 2 Distribution of the number of exporting firms over the number of destination markets, 2004–2014

The single largest destination market is France with an export share of 15%, with Denmark being the second most important. For the firm-destination level, it varies how many destinations each firm is engaged in. As shown in Figure 2, a large share (82%) of the exporters is active in less than 10 markets, indicating a high degree of specialization in terms of which markets a firm serves. This is a strong indication that market-specific fixed costs are present in line with Melitz (2003). Only seven firms (2.4%) are active in more than 50 destination markets. These seven firms make up about 54% of the total export value. Such high skewness in the distribution of firms across markets is in accordance with the findings in Eaton et al. (2004) for French exporters, and Bernard et al.

TABLE 1 Number of Norwegian exporters of fresh salmon by distance to market, 2004–2014

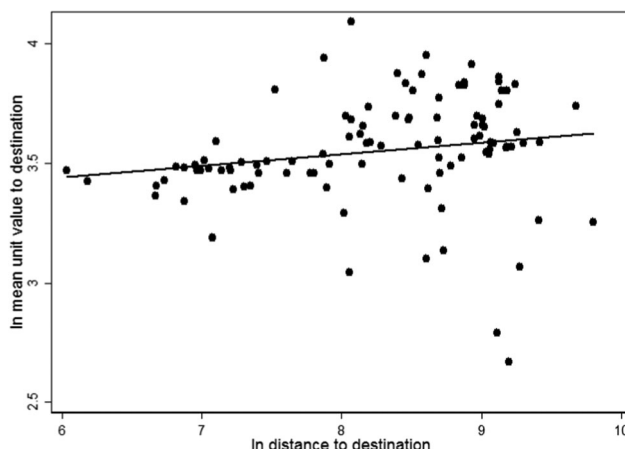| Distance (km)	# exporters	Annual # shipments	Annual volume (tons)	Annual value (billion NOK)	Annual unit value
<1000	196	4110	31,913	999	31.63
1000 < distance ≤ 3500	204	5614	52,799	1708	32.26
3500 < distance < 9000	112	4586	11,821	418	35.54
>9000	52	1422	2505	93	35.88

FIGURE 3 Unit price for the various destination countries for salmon, 2004–2014

(2009) for US exporters. Eaton et al. (2004) report that 20% of the firms export to more than 10 markets, and 1.5% to more than 50 markets. Bernard et al. (2009) report an average of 3.3 markets per firm.

Table 1 shows the number of exporters serving markets in four different distance categories with annual averages for some trade characteristics. It is evident that the most distant markets receive a lower volume than closer markets. As distance increases beyond 1000 km (outside of Scandinavia) mean annual volume and value per shipments decrease, while there is a slight increase in mean unit value.

At the firm level, the average number of shipments for a firm is 85 per destination, with a minimum of one, and a maximum of 231,648 over the whole period. Approximately 70% of the exporters report trade relationships involving only one shipment to a specific country. However, these shipments are not very important for total trade as they make up only 0.1% of the total export volume.

There is increasing evidence that Alchian and Allen (1964) "shipping the good apples out" hypothesis applies also at the firm level as markets are being sorted by quality (Feenstra & Romalis, 2014; Hummels & Skiba, 2004). A main explanation for this relationship is that with increasing unit trade costs, quality becomes relatively cheaper. Moreover, Baldwin and Harrigan (2011) show that as the quality of goods increase, so does costs and profitability and such products are better able to penetrate distant markets. In Figure 3, the correlation between the unit price and distance is shown. Even though there is considerable variation in the unit price, there is a clear indication that it is increasing with distance.

The customs declarations include information about the transportation mode across the Norwegian border. For a perishable product such as fresh salmon, a major concern for the exporter is to ensure a timely delivery of the product to the final market. Table 2 describes the different modes of transportation for export of fresh salmon.

For the Norwegian exports of fresh salmon, 91% of the volume is transported by truck and 9% by air. Almost all exporters use truck as the mode of transportation for at least one shipment, while only 40% (115 out of 284), use air transport for at least one shipment. Moreover, as 74% of the shipments are by truck, these shipments are on average larger than those transaction shipped by air.[3] Eaton et al. (2004) argue that, measured by weight, nearly all trade between countries that do not share a border occurs by maritime transport. In this paper, maritime transport is not included as a distinct mode of transportation as there are few observations in this category and since most transactions that are registered as maritime transport are trucks on a ferry. The high perishability makes slow ship transport an irrelevant alternative.

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[3]The dataset uniquely identifies transportation mode in each observation.

TABLE 2   Mode of transportation of salmon exports at the border, 2004–2014

Transport mode	Share of total volume	Share of total value	Share of total transactions	# exporters using mode
Truck	91%	90%	74%	252
Aircraft	9%	10%	26%	115

TABLE 3   Descriptive statistics, number of exporters and shipment frequencies, 2004–2014

	Share of exporters	Number of shipments	Average value per shipment (NOK)	Average weight (tons) per shipment	Average unit value (NOK) per shipment
EU	0.79	489,570	247,164	7.8	32.0
Non-EU	0.70	425,173	196,526	5.9	34.4
Large GDP	0.91	694,775	251,348	7.4	32.8
Small GDP	0.66	219,968	173,540	5.3	33.9
Large exporters	0.02	532,553	193,257	6	32.8
Small exporters	0.98	382,190	265,946	8.2	33.5

Abbreviation: GDP, gross domestic product.

To get a better understanding of the dynamics between the final destination markets, the number of exporters to different markets, shipment frequencies, and different destinations are grouped according to whether they are members of the EU as this may reduce trade cost,[4] and by the size of their gross domestic product (GDP), as GDP is the most common measure of market size in the gravity literature. In addition, the exporters are grouped according to the number of employees as a measure of firm size. Table 3 shows that 79% of the exporting firms trade with the EU, and 91% of the exporting firms trade with countries with "Large GDP." A destination market has a large GDP if the GDP is above the first quartile of the distribution of the GDP of the various countries. The 2% largest exporters, five different firms, make up 50% of the total export value. These five exporters are classified as large, the rest as small exporters. Not surprisingly, there is a large difference between the numbers of shipments by firms to the EU countries compared to non-EU countries. The highest average unit prices are observed to markets outside of the EU. The large exporters are, as anticipated, more active measured by the number of shipments than the smaller exporters. More interestingly, the largest exporters ship salmon with substantially lower average unit value and average weight per shipment than the smaller exporters. The average unit value is also largest for the small exporters.

The GDP data is taken from the World Bank Development Indicators (WDI).[5] Data for internal distance and share of urban population within a country are obtained from the WDI. Several trade cost variables are included in the analysis. Data for distance is taken from the CEPII-database,[6] while the data on monetary and time trade costs per shipment follows Hornok and Koren (2015) and are obtained from the World Bank's Doing Business Survey. Table 4 summarizes the explanatory variables used in the various model specifications.

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[4]Norway is a member of the European Economic Area (EEA).

[5]The WDI-database is found at http://data.worldbank.org/data-catalog/world-development-indicators.

[6]The CEPII-database is found at http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp.

TABLE 4 Descriptive statistics, explanatory variables—Firm-country level, 2004–2014

Variable	Mean	SD	Min, max	Max
Distance (km)	3310	3253	417	17,991
GDP (100.000.000 USD)	14,638	18,444	3.8	147,966
Dummy, EU	0.53	0.49	0	1
Time cost	11	6.2	4	112
Monetary cost	1062	459.1	367	6452
Internal distance (1000 sq.km)	1346	3658	0.028	16,400
Urban population (millions)	55	105	0.02	742
Transportation mode	0.31	0.46	0	1

Note: Time cost are measured in days and monetary costs in USD per container (http://www.doingbusiness.org/). Transportation mode equals 0 for truck and 1 for air transport.

Abbreviation: GDP, gross domestic product.

3 | MODEL SPECIFICATIONS

The empirical analysis is conducted in two parts. First, gravity models at the firm-to-country level are estimated to explain the trade patterns for salmon from Norway to different markets.[7] Second, several margins of trade are investigated more closely.

The empirical analysis is carried out for firms' export to specific destinations during a specific month. The baseline gravity type model is given as

$$\ln(S_{f,j,t}) = \beta_0 + \beta_1 \ln(Distance_j) + \beta_2 \ln(GDP_{j,t}) + \beta_3 EU_{j,t} + u_{j,t}, \tag{1}$$

with $f = 1, ..., 274$, $j = 1, .., 102$, and $t = 1, .., 132$.

Here, $S_{f,j,t}$ is the export value of fresh salmon from Norwegian firm f to destination j in period t. *Distance$_j$* is the log of the geographical distance between Norway and the destination market. *GDP$_{j,t}$* is the gross domestic product (GDP) in real US\$-prices in destination market j in period t. *EU$_{j,t}$* is a dummy variable for trades to a destination market within the European Union.[8]

The geographical distance is intended to capture transportation costs. As distance increases, so do transportation costs, and sales are expected to drop. *GDP* measures the economic size of the destination market, and is expected to be positively correlated with sales. The EU-dummy captures the potential effect from the free trade agreement Norway has with the EU. We know that a large share of export of salmon from Norway is targeted for EU-countries, so the dummy for trade to an EU-market is expected to be positively correlated with sales.

A number of studies have extended the basic gravity model by introducing additional variables to explain additional cost elements associated with different trade patterns. Lawless (2010a) and Hornok and Koren (2015) use data from World Bank's Doing Business Survey to capture the effect from administrative costs of trade on trade value and on the margins of trade. The literature also indicates that many of the trade costs are per-shipment costs (Hummels & Skiba, 2004; Irarrazabal et al., 2015). For exports at the firm level, Kropf and Sauré (2014) show that per-shipment costs are important for the shipment frequency. Hornok and Koren (2015) find that per-shipment costs are associated with less

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[7]Note that our approach follows the newer firm-level literature building on the literature starting with Melitz (2003), a literature that deviates from the Anderson and van Wincoop (2003) since the focus is at the firm-level and not in on bilateral country-country trade. Chaney (2008) and Arkolakis et al. (2012) shows that the Melitz (2003) model yields a gravity type of equation for total trade flows.

[8]The dummy equals 1 if the country is a member of EU in the respective year.

frequent and larger shipments. Hummels and Schaur (2013) emphasize the importance of time to export (e.g., handling and custom clearance procedures) as an important trade costs. This is particularly relevant for non-storable perishable goods such as fresh salmon as the time it takes to export from the producer to the final buyer can be a critical success factor, as delays may reduce quality or shelf life. To capture per-shipment costs we follow Hornok and Koren (2015) and use the number of days to clear customs for imports, and the cost of importing a container as measures for per-shipment costs. Days required to import are a time cost (*Time cost*), while the cost of importing a container is a monetary cost (*Monetary cost*). The area, measured in square kilometers, of the destination country (*Size*) is included to supplement geographical distance as the proxy for transportation costs. This variable adds the role of internal transportation costs in the destination country. The share of the population living in large cities (*Urban population*) could mitigate such internal transportation costs as costs are reduced if one can concentrate on serving a few large cities relatively to many smaller distant cities. Following Lawless (2010b), it is expected that sales will be negatively impacted by increased internal transportation costs, and therefore positively correlated by the share of urban population. A dummy-variable is also used to capture the mode of transportation *DMode*,[9] which take the value zero when trucks are used for transportation, and one when aircraft is used.

With all these additional variables, the most general model to be estimated is given as

$$\ln(S_{f,j,t}) = \beta_0 + \beta_1 \ln (Distance_j) + \beta_2 \ln (GDP_{j,t}) + \beta_3 EU_{j,t} + \beta_4 \ln (Timecost_{j,t}) + \beta_5 \ln (Monetarycost_{j,t}) + \beta_6 \ln (Size_j) + \beta_7 \ln (Urbanpopulation_{j,t}) + \beta_8 DMode_t + u_{j,t},$$ (2)

with $f = 1, ..., 274$, $j = 1, .., 102$ and $t = 1, .., 132$.

This equation will be estimated in addition to the baseline gravity model in Equation (1). To show the impact of the different groups of trade cost variables, a set of intermediate models where each of these groups of variables are added to the baseline model will be estimated.[10] In the next section we first present the results from estimating (1) and (2) based on the firm-to-country level data. To investigate the different margins in more detail, Equation (2) is estimated with various margins as dependent variables.

4 | EMPIRICAL RESULTS

The results for the gravity models estimated at the firm-country level are reported in Table 5.[11] With trade value as the dependent variable, the baseline model is reported in column two as Model 1. The third, fourth, and fifth columns in Table 5 report the results for the extensions of the baseline model. In Models 2 and 3 per-shipment costs, internal trade costs, and transport mode are included and finally in Model 4 the most general gravity model is reported. Model 5 is the gravity model with traded quantity used as dependent variable.

For the baseline model (Model 1), the results show a large significant negative effect from increased geographical distance on the total export sales of salmon. The distance effect is relatively stable in all model specifications with a parameter in the −0.7 to −0.9 range. This is substantially higher than we obtain for standard commodities. Lawless (2010c) and Bernard et al. (2014) report distance parameters around −0.4, and Hornok and Koren (2015) reports parameter values in around −0.4 for Spain and an even lower magnitude for the United States. Hence, our estimates of the distance effect are about twice as high as what is reported in the general trade literature. This strongly suggests that distance do matter more for perishable products in accordance with the conventional wisdom (Berthelon & Freund, 2008), suggesting that there must be other factors explaining the increased trade with highly perishable products.

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[9]As a few countries receive salmon by truck and air, these countries we will have two observations in the same period when both modes are used.

[10]In line with Hornok and Koren (2015) we do not account for zeros in trade.

[11]We have also estimated the models on a country-to-country level. Results can be provided upon request.

TABLE 5 Gravity model of Norwegian salmon export—Firm-to-country level data

	(1) Baseline model	(2) Including per-shipment costs	(3) Other trade costs	(4) Full model	(5) Full model— weight
ln distance	−0.85***	−0.91***	−0.83***	−0.81***	−0.68***
	(0.05)	(0.05)	(0.07)	(0.07)	(0.04)
ln GDP	0.58***	0.61***	0.57***	0.62***	0.29***
	(0.03)	(0.03)	(0.06)	(0.08)	(0.05)
Dummy, EU	0.20**	0.03	−0.19	−0.29**	−0.21**
	(0.09)	(0.10)	(0.11)	(0.12)	(0.09)
ln Time cost	–	−0.18**		0.14	0.12
	–	(0.09)		(0.12)	(0.07)
ln Monetary cost	–	−0.31***		−0.50***	−0.31***
	–	(0.11)		(0.11)	(0.08)
ln size	–	–	−0.31***	−0.30***	−0.17***
	–	–	(0.02)	(0.03)	(0.02)
ln urban population	–	–	0.36***	0.32***	0.28***
	–	–	(0.08)	(0.09)	(0.06)
Transportation mode	–	–	−0.88***	−1.15***	−1.05***
	–	–	(0.11)	(0.12)	(0.11)
Constant	−8.12***	−5.53***	−9.87***	−7.42***	6.33***
	(0.88)	(0.98)	(1.04)	(1.14)	(0.69)
Observations	54,233	49,256	54,233	49,256	49,256
Adj-R^2	0.35	0.34	0.37	0.37	0.41
F-test	75.61	68.25	98.70	94.53	162.74
Firm FE	Yes	Yes	Yes	Yes	Yes
Month_Year FE	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors clustered on (firms, country) in parentheses.

Abbreviation: GDP, gross domestic product.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

As expected, there is a strong positive relationship between GDP as a measure of market size in the destination market and export sales. When it comes to the per-shipment costs, the increased monetary costs have a significant negative effect on export values, while the time cost is not significant. Also, here the increased internal transportation costs in the destination markets significantly reduce export sales while the reduction in cost associated with urban areas increases sales. The use of airfreight as transportation mode reduces exports. The EU-dummy shows a negative and significant effect on export sales in the full models. This indicates that even though EU-markets are very important for the aggregated sales value of salmon, markets outside of the EU provides a larger scale for those firms that serve them. As we know that distance chokes off trade this indicates that scale in export important for other European markets, especially we know that demand for salmon has been

increasing in the Eastern part of Europe during this period. However, it is interesting to note how the parameter on the EU-dummy change as additional transportation and transaction cost variables are introduced, indicating that these capture information proxied by this dummy in the more restricted models.

There exists a global market for salmon with a common price determination process (Asche & Smith, 2018; Asche et al., 1999; Salazar & Dresdner, 2021), as may be expected for a relatively homogenous product. Moreover, if quality becomes relatively cheaper with higher transportation costs (Hummels & Skiba, 2004), it is not obvious that trade value is the best dependent variable. We will therefore also estimate the gravity model with exported quantity as the dependent variable, as reported in the final column of Table 5 (Model 5). All parameters have the same sign as in the gravity model with traded value as the dependent variable. However, most parameters have a lower magnitude. Still, the distance effect at −0.68 is substantially higher than in the general literature.

4.1 | Extensive and intensive margins

In this section we follow Lawless (2010a) in reporting the extensive margin as number of active exporters. In addition, several intensive margins introduced by Lawless (2010a) and Hornok and Koren (2015), number of shipments, shipment size by weight and value, and unit price, are reported. The results are given in Table 6.

The first margin reported is numbers of firms serving a market (Model 1). Increased geographical distance strongly reduces the number of active firms, and the number of exporters' increases as the market size increases. These results are in line with the findings of Bernard et al. (2007) and Lawless (2010a). Melitz (2003) stress the importance of trade costs when a potential exporter considers a specific foreign market. The results show that particularly the monetary trade cost is important for the number of exporters, although all the different trade costs appear to be important. Urban population has a strong and positive effect, which we interpret as a substantial reduction in trade costs associated with urban areas. The strong impact of the distance variable and trade costs on the number of exporters may also suggest that the more recent geographical expansion of the salmon market involving deeper relationships is due to rapidly increasing costs associated with distance.[12]

The second margin reported is shipment frequency (Model 2). The most interesting result here is that market size has a strong positive effect on shipment frequency. The magnitude of the distance effect is much smaller for this margin, although still statistically significant. Two other elements of trade cost are also important; monetary cost and internal market size. Transport mode is strongly significant indicating a reduction in shipments when much costlier air transport is used.

The next two margins (Models 3 and 4) are the average shipment size by weight and value. The distance parameter and the trade mode indicate negative impacts of these variables, although the magnitudes of the parameters are relatively small. The various trade cost measures and market size are not statistically significant and do not seem to play any role for shipment size.

The unit price is the final margin we investigate (Model 5). As expected, there is a significant positive relationship between distance and unit price. An explanation for this is that one is "shipping the good salmon out" as the most distant markets get the highest quality. Moreover, there is a positive relationship for monetary and time-related trade costs and airfreight, and a negative relationship for urban population (where higher population reduced trade cost), indicating that also these costs promote higher quality.

For all the intensive margins, the most striking result is the small magnitude of the distance parameters, even though they are all statistically significant and with the exception of unit price, negative. This is in sharp contrast to Hornok and Koren (2015), and suggests that the margins have different influences for a fresh product. That shipment size is only weakly influenced by distance and not at all by other trade costs and market size is worth

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[12]Kvaløy and Tverås (2008) and Larsen and Asche (2011) provide evidence of deeper vertical relationships in salmon supply chains.

TABLE 6 Margins of trade—Firm to country level data

Dependent variable	(1) ln # exporters	(2) ln # shipments	(3) ln mean weight	(4) ln mean value	(5) ln price
ln distance	−0.43***	−0.11***	−0.01**	−0.02**	0.03***
	(0.02)	(0.03)	(0.00)	(0.01)	(0.00)
ln GDP	0.10***	0.29***	0.01	0.02	0.01
	(0.03)	(0.03)	(0.01)	(0.01)	(0.00)
Dummy, EU	−0.13***	−0.12**	−0.01	−0.02	0.02**
	(0.03)	(0.05)	(0.01)	(0.02)	(0.00)
ln Time cost	−0.13***	0.01	0.01	0.02	0.02**
	(0.04)	(0.05)	(0.01)	(0.02)	(0.00)
ln Monetary cost	−0.35***	−0.19***	−0.01	−0.01	0.01**
	(0.03)	(0.04)	(0.01)	(0.01)	(0.00)
ln size	−0.10***	−0.12***	0.00	0.00	−0.00
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
ln urban population	0.24***	0.04	−0.01	−0.00	−0.01**
	(0.03)	(0.03)	(0.06)	(0.01)	(0.00)
Transportation mode	−0.11***	−0.26***	−0.04***	−0.07***	0.05***
	(0.03)	(0.06)	(0.01)	(0.02)	(0.00)
Constant	3.66***	−3.97***	9.37***	21.72***	2.66***
	(0.28)	(0.43)	(0.01)	(0.19)	(0.05)
Observations	49,256	49,256	49,256	49,256	49,256
Adj-R^2	0.56	0.37	0.83	0.83	0.80
Firm FE	Yes	Yes	Yes	Yes	Yes
Month_Year FE	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors clustered on (firms, country) in parentheses.
Abbreviation: GDP, gross domestic product.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

emphasizing. In addition, shipment frequency is strongly influenced by market size. This indicates that salmon exporters do not increase shipment size to counter higher trade costs in larger markets, they primarily increase shipment frequency.

5 | CONCLUSIONS

In recent years, trade has increased substantially for a number of highly perishable food products. One will expect that the factors influencing the trade patterns with these products are weighted differently from what is the case for storable products. In particular, shipping time becomes more important because of the perishability. Conventional wisdom suggests that this makes distance a larger impediment to trade and also

that it is harder to exploit economies of scale in transportation as the fewer shipments that are associated with larger shipments also increase transportation time, potentially reducing quality. In this paper, gravity type models as well as a number of margins of trade is used to investigate the trade patterns for one successful highly perishable product—fresh salmon from Norway. The analysis is conducted at the firm-to-country level.

In the gravity models we find that transportation cost as measured by distance matters substantially more than what is reported in the literature for storable products, in accordance with expectations. At magnitudes between −0.81 and −0.91, the distance parameter is about twice the size of the about −0.4 that is normally reported in the literature.[13] When variables that capture per shipment cost and potential transportation costs within a market are introduced, they further increase the importance of transportation costs. On the other hand, the presence of urban areas reduces transportation cost and increase trade. As most firms serve relatively few markets, this is a strong indication that a substantial part of the cost is a market-specific investment that is captured by the firm specific effects, and underlines the importance of the fixed cost component in serving a market, as suggested by Melitz (2003).

Another important feature of the trade patterns is the number of exporting firms operating in various destinations, i.e. the extensive margin. The results indicate that border-to-border as well as transportation costs inside the importing country have a strong negative impact on the number of firms operating in a given destination market. When it comes to the exporters' intensive margins, the distance effect becomes much weaker. For shipment size, other trade costs are all statistically insignificant. Together with a strong market size effect on shipment frequency, this indicates that increased trade results in higher shipping frequency. One can exploit economies of scale by increasing shipment frequency to a large extent. With the important role of transportation costs, it is as expected that quality sorting is important and quality increase with distance.

The results provide clear indications that trade patterns for a highly perishable product like fresh salmon is very different from storable bulk commodities. Distance cannot to the same degree as for storable products be overcome by exploiting scale, even though trade costs appear to be reduced to some extent by targeting larger markets and urban areas. Hence, the general increase in trade with highly perishable products appears to be due to innovations that makes transport of such products so much cheaper that they become competitive. The most striking insight is that with increased market size the shipment frequency increases while there is no impact on shipment size, increasing the average freshness of the product available in the market but also illustrating that economies of scale in transports are not utilized for these products. Hence, the trade-off between quality and potential losses due to unsold products and transportation cost associated with scale appears to be tilted in favor of freshness. While the observed trade patterns deviate in important aspects from the trade patterns of bulk products, the differences all make sense when accounting for the fact that the traded product is relatively high valued and highly perishable. While not directly generalizable, the results are accordingly likely to provide insights also for the trade with other high value fresh products like blue berries and asparaguses.

PEER REVIEW

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[13]It is of interest that relative production cost and transportation cost can also influence supplier structure. For instance, Norman-López & Asche (2008) show how the US market for fresh tilapia is dominated by central American suppliers, while frozen tilapia primarily comes from Asia.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Statistics Norway. Restrictions apply to the availability of these data, which were used under license for this study.

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