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Agglomeration and trade performance – evidence from the Norwegian salmon aquaculture industry

Ivar Gaasland[a], Hans-Martin Straume[a], and Erling Vårdal[b]

[a]Department of Economics, BI Norwegian Business School, Oslo, Norway; [b]Department of Economics, University of Bergen, Bergen, Norway

ABSTRACT

Geographical concentration of industries tends to be important for firms that depend on innovation and are intensive in the use of specialized technology and labor. In this paper, we investigate the interaction between agglomeration and trade performance in the Norwegian aquaculture industry. We include a variable for regional clustering in a standard gravity model and estimate its impact on different margins of trade. When controlling for destination country, we find that firms that operate in clusters obtain higher export prices and ship more frequently and in smaller bulks. For a highly perishable product like fresh salmon, this may suggest that firms in clusters are served by more efficient supply chains bringing the product to market with timely and efficient logistics.

KEYWORDS

Aquaculture; agglomeration; export prices; trade margins

Introduction

Since Alfred Marshall's early observations of industrial districts in England (Marshall & Marshall, 1920), it has been recognized that positive or agglomeration externalities (synergies) may arise between firms located in the same area (clusters). Such external economies of scale tend to reduce the industry's unit costs, even in circumstances with no economies of scale at the firm level. Consequently, firms may achieve benefits from being located within a cluster, which serves as a competitive advantage in production and trade. Access to specialized physical and human capital, and thicker markets for complementary firms, as well as knowledge spillovers, are standard explanations used in the literature to explain agglomeration benefits (Porter, 1996). Agglomeration is typically important for firms that depend on innovation and are intensive in use of specialized technology and labor (Porter, 1996). Békés and Harasztosi (2013) also show that benefits from clustering tend to be larger for firms that operate in international

CONTACT Hans-Martin Straume hans-martin.straume@bi.no Department of Economics, BI Norwegian Business School, Oslo, Norway.

markets. Both these factors are potentially important in salmon aquaculture as it is a knowledge driven and export oriented industry (Asche, 2008; Asche & Smith, 2018; Kumar & Engle, 2016).

While most of the focus has been on productivity growth in the production phase (Asche & Roll, 2013; Asche, Roll, & Tveteras, 2009; Rocha Aponte & Tveterås, 2019; Roll, 2013; Tveteras, 1999; Vassdal & Holst, 2011), the importance of innovation in the supply chain (Asche, Cojocaru, & Roth, 2018; Asche, Roll, & Tveteras, 2007; Kvaløy & Tveteras, 2008; Olson & Criddle, 2008) and demand growth have also been recognized (Asche, Dahl, Gordon, Trollvik, & Aandahl, 2011; Braekkan, Thyholdt, Asche, & Myrland, 2018; Braekkan & Thyholdt, 2014).[1,2] There are also a few studies that more specifically investigate agglomeration effects at the production level in Norwegian salmon aquaculture. Using different model specifications, Tveteras (2002), Tveteras and Battese (2006), and Asche, Roll, and Tveteras (2016) find evidence of agglomeration, but that this is limited to the salmon industry.

The Norwegian salmon aquaculture industry is a highly export oriented industry. During the period 2004–2014, about 90% of the Norwegian salmon production was exported to more than 70 countries. While there is a global market for salmon (Anderson, Asche, & Garlock, 2018; Asche, Bremnes, & Wessells, 1999), the size of the individual markets varies significantly, as do preferences for various product attributes (Alfnes, Chen, & Rickertsen, 2018; Anderson & Bettencourt, 1993; Ankamah-Yeboah, Nielsen, & Nielsen, 2016; Asche, Larsen, Smith, Sogn-Grundvåg, & Young, 2015; Bronnmann & Asche, 2017; Roheim, Sudhakaran, & Durham, 2012; Uchida, Onozaka, Morita, & Managi, 2014), characteristics of the supply chains (Larsen & Asche, 2011; Straume, 2017; Xie & Zhang, 2014), exchange rates (Straume, 2014; Tveteras & Asche, 2008; Zhang & Kinnucan, 2014) and price shocks (Asche, Misund, & Oglend, 2020; Asche, Oglend, & Kleppe, 2017; Dahl & Oglend, 2014).

In an export oriented sector like Norwegian salmon production, supply chain elements and trade performance can be important. For instance, Asche et al. (2007) note that more efficient logistics contribute to the completeness of the salmon relative to the cod industry. As noted above, salmon is a heterogeneous commodity demanded by customers with different product attribute requirements (e.g. size, quality, freshness, regularity), calling for supply chains that are targeted to various markets. Better access to high-skilled labor could serve to increase the quality and align product attributes to the requirements and valuations in different markets. Innovation and higher labor productivity that typically increase the labor costs would also give incentives to supply higher quality products (Combes, Duranton, & Gobillon, 2011). Furthermore, since fresh salmon is a highly perishable product, access to efficient supply chains is crucial. Norwegian fresh salmon is exported worldwide and has to be consumed within a timeframe of 20 days. Firms in clusters could learn from each other, e.g. how to get access to networks and more efficient supply chains (Bisztray, Koren, & Szeidl, 2018). Ramos and Moral-Benito (2018) also find that agglomeration is most valuable to firms seeking to penetrate difficult markets, as agglomeration may reduce destination specific fixed costs.

In this paper, the focus is on the potential agglomeration effects in relation to salmon trade, and a gravity type of model is, therefore, used.[3] We include a variable for regional clustering into the gravity model and estimate its impact on important margins of trade by decomposing export value into the exporters' achieved price (unit value), shipment volume, and number of shipments. In accordance with the above discussion, we hypothesize that firms that operate in clusters achieve higher export prices when controlling for destination country (gravity variables). Furthermore, we expect that export prices increase with distance in accordance with the Alchian and Allen (1964) hypothesis that it is relatively cheaper to supply quality in distant markets since unit transportation costs are higher.

The paper is organized as follows. In the next section "The salmon industry", we provide a brief survey of the Norwegian salmon industry with focus on information relevant to our study. The method and data employed are described in Section "Empirical approach and data", followed by empirical results in Section "Empirical results". Main results are summarized in Section "Conclusions".

The salmon industry

The Norwegian coastline is the second largest in the world, with a total of 102,937 km. The proximity to the Atlantic Ocean, together with a geographical location in the north that ensures a low stable water temperature, makes the Norwegian coast ideal for farming Atlantic salmon. In 2014, there existed about 3,700 pens for aquaculture production in approximately 800 different locations along the Norwegian coastline (Statistics Norway, 2019).[4] The major part of the production takes place in nine different counties along the coast. Figure 1 shows the aggregate export value for the estimation period 2004–2014. Some background statistics at the county level (sorted by the cluster index value) for the last year in our time series (2014) are provided in Table 1. Figure A1 in the appendix provides a map of the geographical locations of the different counties.

As illustrated in Figure 1, the production value varies substantially between the nine regions. This is also the case for the cluster index (first column in Table 1) which is calculated as the number of production licenses in a region divided by the size of the region's coastline. We can

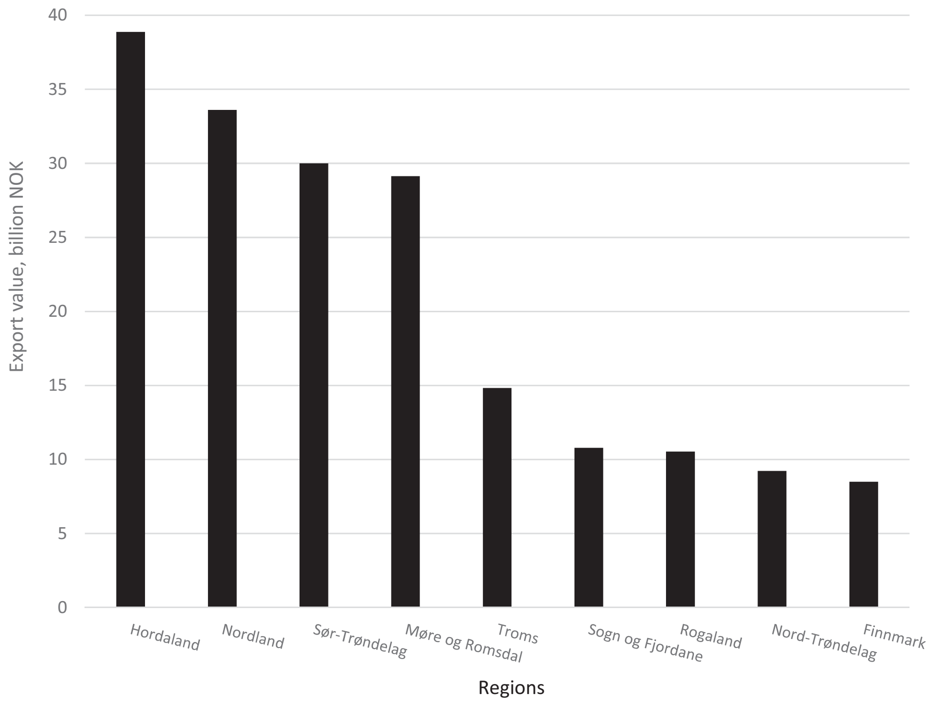

Figure 1. Aggregate export value by production counties (2004–2014). *Note*: Production registered in regions with <1% of export value is deleted. The remaining production make up 99.6% of the export value.

Table 1. Summary statistics (2014).

Production region (county)	Cluster index value	Export value (million NOK)	Average unit value (NOK per kg)	# Exporters	Number of licenses	Herfindahl index	Export value per exporter
Sør-Trøndelag	100	4,696	39.7	31	104	0.028	151.5
Hordaland	96	5,734	41.3	38	165	0.042	150.9
Troms	70	2,530	40.6	39	97	0.008	64.9
Møre og Romsdal	69	3,491	41.5	43	121	0.020	81.2
Rogaland	59	1,098	39.8	18	70	0.002	61.0
Nord-Trøndelag	57	1,502	40.4	30	77	0.003	50.1
Sogn og Fjordane	48	1,321	41.5	27	91	0.002	48.9
Nordland	45	5,589	39.7	40	175	0.040	139.7
Finnmark	32	1,622	41.9	37	90	0.003	43.8

also observe heterogeneity between regions in unit value (third column of Table 1) that measures the exporters' achieved free on board (FOB) price. A possible explanation, more rigorously examined in Section "Empirical results", is that exporters sell different grades of quality; e.g. upgrade quality for distant markets or in general achieve a price premium due to superior market knowledge, networks or efficient supply chains.

While the export value per exporter in column 7 measures the size of the exporters, the Herfindahl index in column 6, defined as the squared sum of each exporters' share of the total export from a region, indicates the degree to which export is dominated by few firms. The correlation between the cluster index and these two measures are positive[5], suggesting that firms that export salmon from regions with a high density of locations are larger and possess a higher share of total export from the region. Recent firm-level trade literature shows that export performance typically increases with the size of the firms (Bernard, Jensen, Redding, & Schott, 2007).

Empirical approach and data

Following Mayer and Ottaviano (2007) and Lawless (2010), we decompose export value into the following margins of trade:

$$X = P * N * Q \tag{1}$$

where X is the total export value, P is the unit value, N is the number of shipments, and Q is average shipment volume, respectively. The number of shipments (N) is in the literature phrased as the extensive margin of trade, while the two latter terms (Q and P) is two distinct elements that together makes up the intensive margin of trade. The export volume is the product of the number of shipments (N) and the average size of each shipment (Q).

The analysis is conducted at the region-destination-year level. The empirical model that we estimate for total export value, and the three margins, is given as

$$\begin{aligned} \ln(Y_{r,m,t}) = \beta_0 + \beta_1 \ln(Distance_m) + \beta_2 \ln(GDP_{m,t}) + \beta_3 \ln(Cluster_{r,t}) \\ + \beta_4(US_t) + \beta_5(UK_t) + \delta_t + u_{r,m,t} \end{aligned} \tag{2}$$

Depending on estimation, the variable on the left-hand side (Y) is either the export value (X) or the different margins of trade (N, Q and P) of fresh salmon exported from production region (county) r to destination country m in period t. $Distance_m$ is the geographical distance between Norway and market m which in standard gravity models enters as a proxy for trade costs. $GDP_{m,t}$ is the gross domestic product in real US$-prices in destination country m in year t measuring the size of its economy. Geographical distance to the destination market and GDP of the destination market are independent variables that are common in the empirical trade literature both for studies that builds on the traditional gravity framework (Anderson & Van Wincoop, 2004), as well as in studies that builds on theories founded at the firm-level (Lawless, 2010; Mayer & Ottaviano, 2007). $Cluster_{r,t}$ measures the degree of agglomeration in production region r. Norwegian exporters have a dominating market share in most markets with the exception of the USA and the UK. We include separate dummies to control for these two exceptions to the Norwegian dominance. Finally,

Table 2. Results from estimation of Equation (2).

	(1)	(2) Disaggregation of export value	(3)	(4) Disaggregation of export volume	(5)
	Export value	Unit value (FOB price)	Export volume	# shipments	Average shipment volume
ln distance	−1.802***	0.057***	−1.858***	−1.294***	−0.565***
	(0.087)	(0.004)	(0.087)	(0.069)	(0.043)
ln GDP	0.760***	0.000	0.759***	0.620***	0.139***
	(0.049)	(0.002)	(0.049)	(0.038)	(0.024)
ln cluster index	1.179***	0.019***	1.159***	1.537***	−0.377***
	(0.265)	(0.007)	(0.268)	(0.189)	(0.128)
Dummy, US	−2.306***	0.004	−2.310***	−2.710***	0.400*
	(0.350)	(0.020)	(0.357)	(0.278)	(0.209)
Dummy, UK	−0.125	−0.015	−0.109	−0.777***	0.668***
	(0.342)	(0.010)	(0.343)	(0.285)	(0.113)
Constant	11.549***	2.774***	8.775***	1.668	7.107***
	(1.595)	(0.061)	(1.614)	(1.219)	(0.753)
Observations	3,206	3,206	3,206	3,206	3,206
R^2	0.456	0.773	0.454	0.456	0.252
Year FE	Yes	Yes	Yes	Yes	Yes

***$p < 0.01$,
**$p < 0.05$,
*$p < 0.10$.
Robust standard errors clustered at the region-destination country in parentheses.

the two last parts of Equation (2) are time fixed effects and a normally distributed error term, respectively.

To estimate the empirical model, data is collected from numerous sources. Data for export value at the region-destination country builds on transaction level data provided by Statistics Norway.[6] Data for geographical distance are taken from the CEPII-database,[7] while data for *GDP* are taken from the World Bank Development Indicators[8] (WDI). To construct the cluster variable we source data on the number of production licenses at the regional level from The Norwegian Directorate of Fisheries[9] while data for the size of each regions coastline is obtained from the Norwegian Mapping Authority.[10] Table A1 in the Appendix provides the main characteristics of the data used to estimate Equation (2).

Empirical results

The empirical model is estimated using OLS, and the results are given in Table 2. Note that in accordance to Equation (1) (on logarithmic form), the coefficient for export value is the sum of the coefficients for unit value and export volume, respectively, while the coefficient for export volume is the sum of number of shipments and the average shipment size.

With respect to the gravity variables, the first three columns show that Norwegian fresh salmon exports follow a similar pattern to what is found in most empirical studies. Exported volume declines with distance (indicating trade costs) as expected, but the very strong effect is notable, as the parameter tends to be around 1 for manufacturing products (Anderson &

Van Wincoop, 2004). However, the result is reasonable given the high degree of perishability of fresh salmon. As predicted by the general literature, the export value increases with the size of the destination economy (indicating the size of the market), and here the magnitude is more in line with the general literature. The exporters' FOB price (unit value) increases with distance in accordance with the Alchian and Allen (1964) hypothesis that it is relatively cheaper to supply quality in distant markets since unit transportation costs are higher. Recently, Manova and Zhang (2012) used a gravity model to show that Chinese exporters typically upgrade quality and charge higher prices in larger and more distant markets. The importance of the number of shipments relative to shipment size is also highly interesting. Normally, economies of scale in transportation is the most common mean to overcome higher transportation costs associated with distance (Behar & Venables, 2010). However, this option is to a much lesser extent available for a perishable product like fresh salmon. The last column in Table 2 confirms that average shipment volume declines with distance, which implies more frequent shipments per unit exported.

The next variable listed in Table 2 is the cluster index. Clusters are difficult to measure directly. As mentioned earlier we have calculated clusters indirectly as the number of production licenses in a region divided by the size of the region's coastline. Since both these variables are exogenous, so is the cluster index. In a specific region the coastline is given, so an increase in the cluster index must be caused by an increase in the number of production licenses to that region. Naturally, an increase in the number of licenses is expected to increase production, and, thereby, the volume of export. Furthermore, it will increase the concentration of production, and this cluster effect is expected to give an extra impetus to export. So is hardly surprising when we from Table 2 see that the cluster index variable has a regression coefficient above one and proves to be highly significant.[11]

Our main indicator of trade performance is the exporters' achieved FOB price (unit value) in a destination. As the second column in Table 2 shows, the cluster variable has a positive and significant impact on the price exporters achieve in a specific market. There are several reasons for this observation. One explanation may be that firms in regions with high firm density on average benefit from lower transportation costs. However, the potential to supply better quality may also play a role. This is suggested by the disaggregation of export volume into shipment frequency and average shipment size given in columns 4 and 5. We see that firms in cluster regions on average ship more frequently and in smaller bulks. For a highly perishable product like fresh salmon, this may suggest that firms in clusters enter into more efficient supply chains that serve markets timelier, ensuring a fresher product.

Looking at the overall picture in Table 2, the results for the unit price is striking. For this equation the degree of explanation, measured by R^2, is by far the highest. We have demonstrated that price increases with distance and clusters, reflecting a quality aspect. However, the contribution of the constant term is by far highest. Therefore, there is a strong tendency toward prices to be constant. The strong distance effect means that this constant-price-tendency is mainly true within national markets. For more distant markets, prices are higher. Also, exporters from regions with high density sell to a relatively higher price.

Conclusions

As a knowledge intensive and export oriented industry, salmon producers have the potential to benefit from agglomeration externalities. The existence of industry clusters in Norwegian aquaculture has indeed been demonstrated in production (Asche, Roll, & Tveteras, 2016; Tveteras, 2002; Tveteras & Battese, 2006). However, while there has been significant focus on how the control with the production process in aquaculture also facilitates efficient supply chains, there have been no attempts to investigate for agglomeration effects downstream from the producer. This is surprising as transportation, logistics and marketing are activities that often are associated with economies of scale as well as network externalities.

In this paper, a cluster index variable is introduced in a gravity model as well as various trade margins estimated on Norwegian firm exports data to test for agglomeration effects in exports. The results give clear evidence of agglomeration effects also in exports. The various margins provide more nuanced information about these effects. In particular, firms that operate in clusters obtain higher export prices and ships more frequently and in smaller bulks. For a highly perishable product like fresh salmon, this may suggest that firms in clusters is served by more efficient supply chains bringing the product to market with timely and efficient logistics. Our results suggest that agglomeration economies should be taken into consideration when the authorities allocate production permits. A challenge for the authorities is then to design regulations that balance benefits from agglomeration against the potentially conflicting objectives related to rural distribution and environmental concerns.

Notes

1. There is also a number of studies investigating price transmission in salmon supply chains, with Landazuri-Tveteraas, Asche, Gordon, andTveteraas (2018) as the most recent example.

2. There is less focus on how new technologies actually are adopted, but Kumar, Engle, and Tucker (2018) provide a review.
3. There are numerous papers utilizing the gravity framework when studying trade in seafood products, see e.g. Natale, Borrello, and Motova (2015) and Asche, Gaasland, Straume, and Vårdal (2019).
4. A small number of the pens were used for farming trout, but the main species is Atlantic salmon.
5. The correlation coefficient between the cluster index value and the export value per exporter is 0.67, while it is 0.52 between the cluster index value and the Herfindahl index.
6. See e.g. Asche, Gaasland, et al. (2019b) and Oglend and Straume (2019) for a detailed description of transaction level data for Norwegian salmon export.
7. The CEPII-database is found at http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp.
8. The WDI-database is found at http://data.worldbank.org/data-catalog/world-development-indicators.
9. https://www.fiskeridir.no/English/Aquaculture/Statistics.
10. https://www.kartverket.no/en/.
11. From Table 2, we see that the measured cluster effect on export volume is 1.159. If licenses are fully utilized, there will be a one-to-one relationship between licenses and production, and the measured effect will then be 1. The additional 0.159 can then be attributed to the second mentioned effect.

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Appendix

Figure A1. Regions within Norway.

Table A1. Main characteristics of the data set.

Number of firms (exporters)	230
Destination markets	73
Shipments	596,998
Regions	9
Years	11