

This file was downloaded from BI Open, the institutional repository (open access) at BI Norwegian Business School <https://biopen.bi.no>

It contains the accepted and peer reviewed manuscript to the article cited below. It may contain minor differences from the journal's pdf version.

Cojocaru, A. L., Asche, F., Pincinato, R. B. M., & Straume, H.-M. (2019). Where Are the Fish Landed? An Analysis of Landing Plants in Norway. *Land Economics*, 95(2), 246-257.

Copyright policy of *University of Wisconsin Press*, the publisher of this journal:

An author may post their preprint version of the article to their institutional repository, provided a link is made available to the journal's website that contains the final published version of the article (in other words, on their preprint, there should be a link to the final, HighWire version of the article after it publishes). The University of Wisconsin Press considers the uncopyedited, untypeset submitted manuscript to be the preprint version.

WHERE ARE THE FISH LANDED?
AN ANALYSIS OF LANDING PLANTS IN NORWAY

Andreea L. Cojocaru ^a, Frank Asche ^{a,b,c,*}, Ruth Beatriz Mezzalira Pincinato ^a, Hans-Martin Straume ^d

Affiliations:

- a. Graduate Student, Department of Safety, Economics and Planning, University of Stavanger, Stavanger 4036, Norway, andreea.cojocaru@uis.com, ruth.b.pincinato@uis.no
- b. Professor, Institute for Sustainable Food Systems and School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611-0180, USA, frank.asche@ufl.edu
- c. Adjunct Professor, Department of Safety, Economics and Planning, University of Stavanger, Stavanger 4036, Norway, frank.asche@ufl.edu
- d. Associate Professor, Department of Economics, BI Norwegian Business School, Bergen 5006, Norway, hans-martin.straume@bi.no

* Corresponding author, e-mail: frank.asche@ufl.edu

WHERE ARE THE FISH LANDED?
AN ANALYSIS OF LANDING PLANTS IN NORWAY

Abstract:

A vast literature in fisheries economics focuses on drivers of fishermen behavior with limited attention given to what happens once the fish are landed. This often strongly contrasts with the main policy focus on coastal communities, with fisheries management an additional instrument in supporting livelihoods. This study shows that the number of Norwegian landing plants has been reduced in recent decades, and that quantity landed, annual plant operation time and attracting smaller vessels, decrease the probability of exit. Interestingly, plants in communities with additional landing locations have lower probabilities of exit, pointing to a cluster effect.

Keywords: fisheries, landing plants, industry cluster

Funding: The authors thank the Norwegian Research Council for financial support.

JEL Classification: Q22

1. INTRODUCTION

There is a vast literature in fisheries economics focusing on what happens on the water and on drivers of fishermen behavior, while limited attention has been given to what happens once the fish are brought aboard a vessel. This is somewhat surprising as in many countries, developed as well as developing, the main policy focus is on coastal communities rather than on fisheries, with fisheries management often playing the role of an additional instrument in supporting livelihoods in these communities (Olson, 2005). Fishermen and coastal communities are frequently shown to be poor or in decline, and interventions through improved fisheries management are surprisingly often portrayed as detrimental (Munk-Madsen, 1998; Copes and Charles, 2004; Olson, 2006; Hersoug, 2011; Tietze, 2016).¹ As a consequence, fisheries management systems tend to build in features that are meant to enhance the social objectives of the fishery, even though they may be economically inefficient (Kroetz, Sanchirico and Lew, 2015). Subsidizing fisheries (Sumaila et al., 2016), allocating individual processing quotas (Matulich and Sever, 1999), community development quotas (NOAA, 2017; NPFMC, 2017), and imposing obligations to land fish in specific communities (Standal and Aarset, 2008; Hermansen and Dreyer, 2010), are some examples of types of management tools meant to help fishery-dependent communities.

When landing their catch, fishermen must choose between different landing plants, invariably associated with coastal communities due to their geographical location. A

¹ Coastal communities that were once built around fishing-related activities are now often perceived to experience a loss of “values” when fishing no longer serves as their principal occupation (Blythe, 2015; Tull, Metcalf and Gray, 2016; Thompson, Johnson and Hanes, 2016).

landing plant can be defined as a connecting node in the fish supply-chain, where catches are landed. At some plants the fish may be further processed, while at others they will just be distributed to the next level in the supply chain. These nodes are also the main link to the coastal communities that are supported by the fishing activity. In struggling coastal communities, at least some of these plants are performing poorly from an economic perspective, and worst case, the coastal community's link to the fishing industry is weakened or interrupted when the last plant closes down. Hence, for coastal policy and communities it is of substantial interest to investigate if there is any factors that help explain which landing plants thrive and which do not.

This paper investigates attributes that may influence landing plants' survival in the Norwegian groundfish sector. The methodology applied is similar to the more general literature for firm survival (e.g. Salvanes and Tveteras, 2004). Similar econometric approaches are also used to investigate choice of fishing location (Bockstael and Opaluch, 1983; Eales and Wilen, 1986; Smith and Wilen, 2003; Huang and Smith, 2014), and choice of fishing gear (Eggert and Tveteras, 2004). A pooled logit model and conditional logit models are used to estimate the probability of a plant becoming inactive in association with a range of attributes. Cox proportional hazard models are applied to identify factors that affect the duration of a landing plant's activity and to estimate the probability of its survival. The analysis is carried out on a dataset containing all groundfish landed in the northern half of Norway, an area comprising the main fishing regions in the country.

The section that follows provides a background for Norwegian fisheries. The next section elaborates the data used and choice of covariates, and continues with a

description of methods. Empirical results are finally reported before concluding remarks are made.

2. BACKGROUND AND DATA

The landing plants that receive groundfish in Norway are spread out along the coast, with some concentration in areas close to popular fishing grounds, such as for cod in the Lofoten islands. Groundfish is the most important fishing sector in Norway, with approximately 50% of the total landed value. Its management system shares many main characteristics with other managed fisheries in the developed world. A Total Allowable Catch (TAC) was introduced gradually for cod and the other main species during the 1980s, to protect the fish stock and stabilize landings (Hannesson, 2013; Standal, Sønvisen, and Asche, 2016).² As shown in Figure 1, since 1995 the landing value in real terms for groundfish has remained relatively stable at about NOK 6 billion per year, although with substantial annual variation. During the same period, the number of landing plants has been reduced by nearly 50%, from 370 to 205. This is not surprising given that the real income level in Norway is increasing (SSB, 2017) and, with a given value of landings, productivity must increase if the plant workers are to continue earning an income competitive with alternative occupations. Over time, the number of fishermen and the number of vessels have also been reduced for similar reasons, and possibly more so due to the gradual movement towards Individual Fishing Quotas (IFQs) (Standal and Hersoug, 2015; Standal, Sønvisen, and Asche, 2016; Hannesson, 2017).

² The TAC was first introduced for trawlers in 1981, and was extended to all vessels by 1989.

The fishery management system in Norway maintains an owner-operated coastal fleet (Standal and Hersoug, 2015), making it illegal for landings plants to own fishing vessels.³ Moreover, the fisheries regulations in the groundfish sector largely favor coastal vessels. For instance, to maintain a fleet structure dominated by coastal vessels and to help prevent geographical concentration in landings, about 70% of the cod quota is allocated to coastal vessels in a formula known as the trawl-ladder, where the coastal fleet receives a higher share of the TAC in years with a lower TAC (Guttormsen and Roll, 2011). Fishermen are also protected from oligopsonistic buyer behavior by sales organizations with a monopoly on first hand sale of fish.⁴ Any buyer must register with these sales organizations that receive payment on behalf of the fishermen, allowing them in turn to enforce a minimum price.⁵

The data used in this paper have been collected and provided by the Norwegian Fishermen's Sales Organization (Norges Råfisklag), the largest of the six sales organizations, whose area extends from the northern-most region of Finnmark to Nord-Møre (Figure A1). They hold the responsibility for all landings of fish and seafood in the northern half of Norway, with the exception of pelagic fish. The raw data contain trip-level landing records for all commercial species transacted under Norges Råfisklag, between 2002 and 2015.

³ There exist a few exceptions for the trawler group. Two companies are allowed to own trawlers with the objective of ensuring that the plants receive sufficient quantities of fish.

⁴ There are six sales organizations: one that handles all pelagic species, and five regional organizations that handle all other fish species.

⁵ While the sales organizations have monopsony power, there is no evidence that this is exploited beyond protecting fishermen from potentially oligopsonistic buyers (Asche, Chen and Smith, 2015; Pettersen and Myrland, 2016).

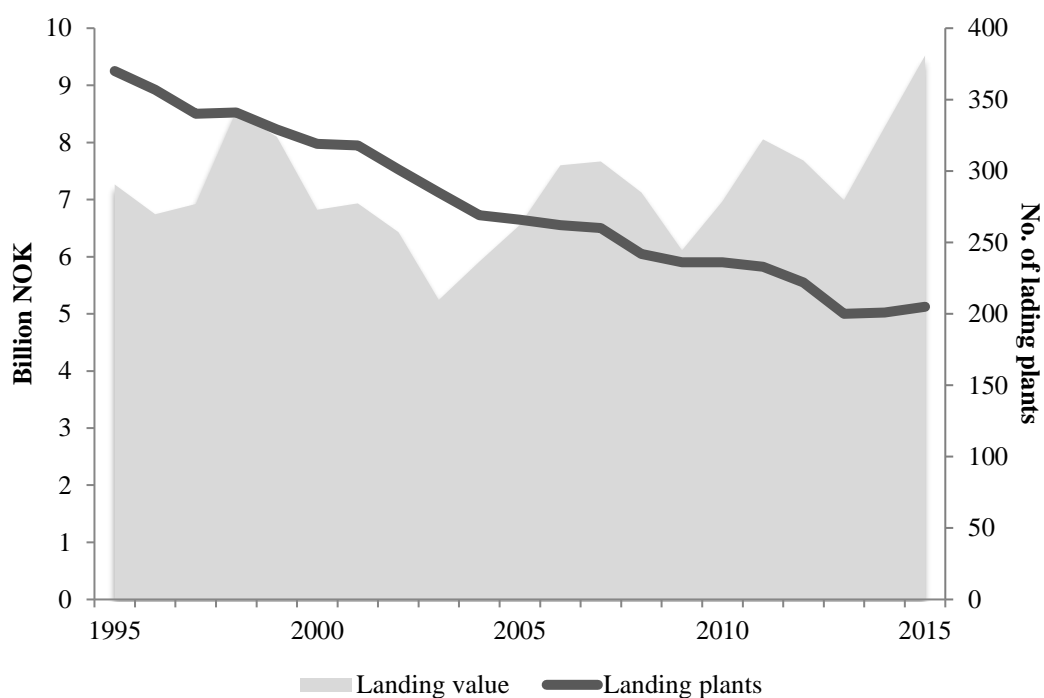


Figure 1: Number of landing plants and landing value for groundfish in Norway

(Source: Fiskeridirektoratet, NOFIMA)

The dataset was aggregated to the level of landing plant, on a yearly basis. The landings cover more than ten target species, some of which are managed with IFQs, some with regulated or restricted open access, some are open access, and a number of them are smaller bycatch species. The main species landed are shown in Figure 2. Cod is by far the most important one by quantity, and even more so when considering value, since it is the highest priced groundfish species. Haddock and saithe are also of significant importance, and together with cod account for over 80% of the landed value.

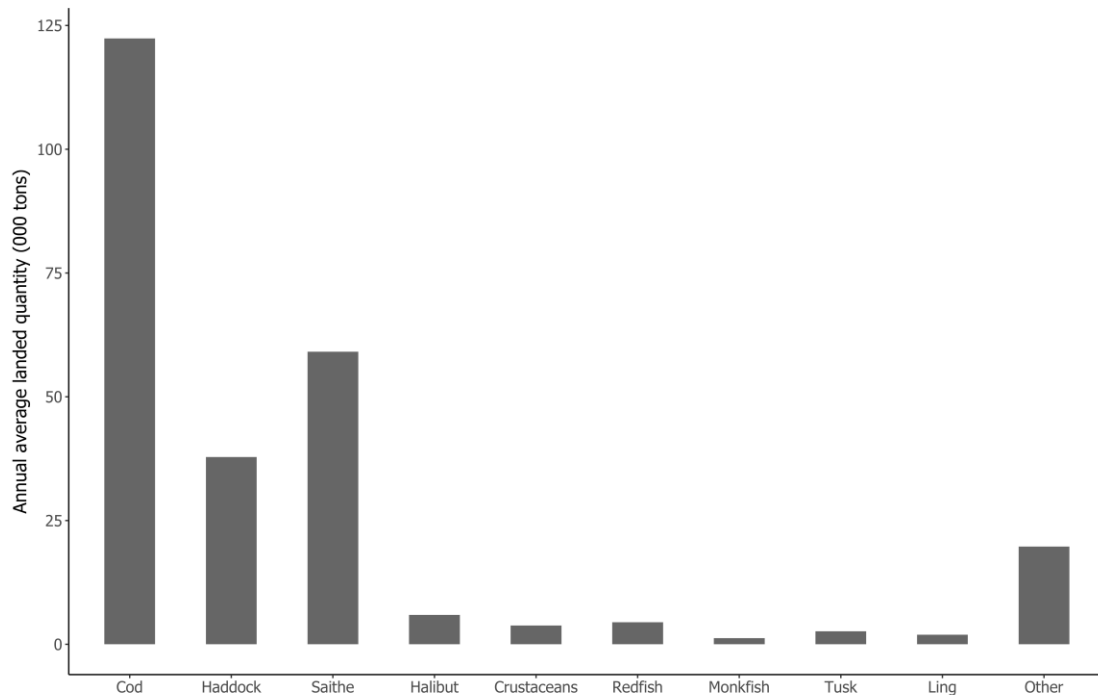


Figure 2: Average yearly quantity landed by species

The coastal fleet is highly dependent on the migration patterns associated with spawning aggregations for the main species, of which the most well known is that for cod in Lofoten during winter and early spring months (Hannesson, Salvanes and Squires, 2010; Kvamsdal, 2016). This gives rise to high seasonality in the fishery as shown for cod in Figure 3, which creates challenges for capacity utilization at a landing plant. While this issue has not in itself received much attention, with Matulich, Mittelhammer, and Reberte (1996) as a notable exception, it is largely a reflection of the over-capacity in the fleet, leading to derby fisheries and short harvesting seasons. A Herfindahl-Hirschman Index (HHI) was constructed to measure concentration of landings over the year for the various plants. This is graphed, by landed quantity, in Figure 4. When seasonality is low and landings are spread out equally over all months, the HHI will have a lower bound at $1/12$, and it will be equal to 1 if all fish are landed in the same month. This is the case for some landing plants

(Figure 4). Similarly, an additional HHI was computed to measure each plant's landings concentration over fish species, to account for the diversity of landed species. In contrast to the HHI for season, the impact of the HHI for species is not so straightforward, as diversification can be a tool to reduce risk, while specialization can reduce cost.

Several vessel types and gears are used in the Norwegian groundfish fleet. Figure 5 shows the annual average landings by gear type, with the number of vessels using the associated gear at the top of each bar. Nets are the gear catching most fish, followed by Danish seine, trawl, and hook and line. Nets and Danish seine are the gears preferred by most of the larger coastal vessels, and their importance for the landings then reflects the importance of these vessels in the fishery. Hook and line is the preferred gear for the smallest vessels, the most abundant in terms of number of vessels. Hence, hook and line are the gears used by most vessels, although they are less important in terms of total landings due to the limited landings per vessel. The trawlers and long-liners land significant quantities despite their relative low numbers, reflecting these vessels' fishing power.

An individual landing plant is defined as a plant receiving fish at a specific geographic location that may or may not conduct additional processing of the fish. In cases where a plant was observed to not receive landings for one year or longer, its re-appearance in the dataset was defined as a new landing plant. The motivation for this decision is based on the fact that landing plants may file for bankruptcy and possibly experience a change in ownership, go through significant management and strategy changes or renovation, in which cases they can be regarded as a new plant.

Communication with Norges Råfisklag indicates that most plants that do re-open do so under new ownership.

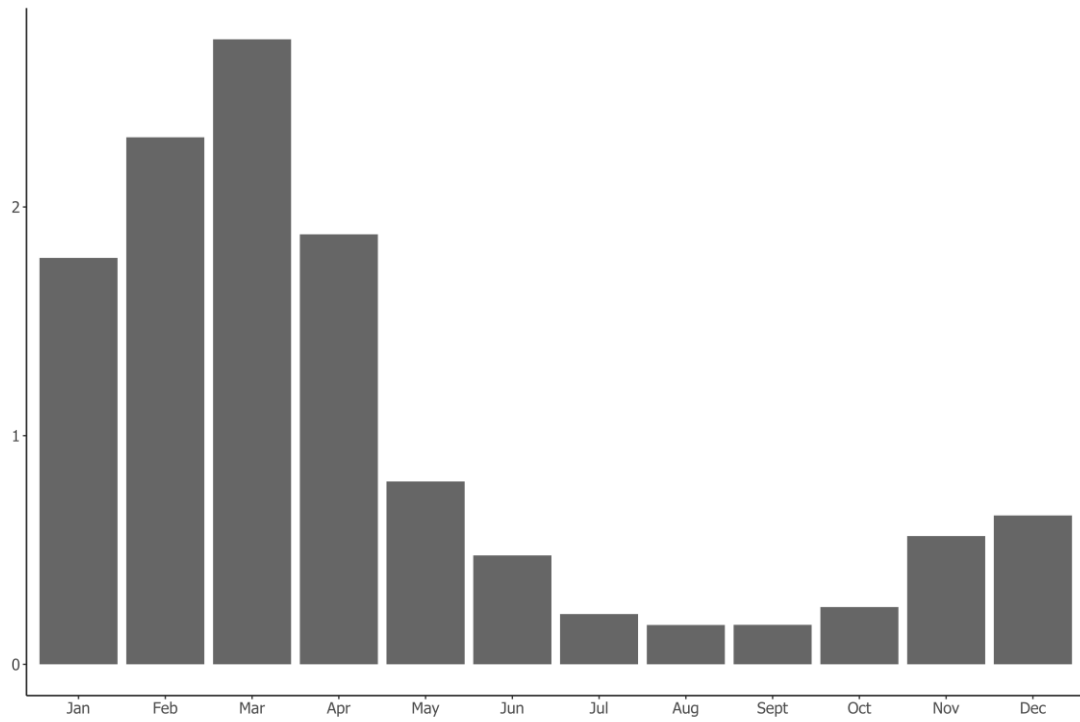


Figure 3. Seasonal landings pattern for cod, 2002-2015. Landings are normalized to average monthly landings across the years.

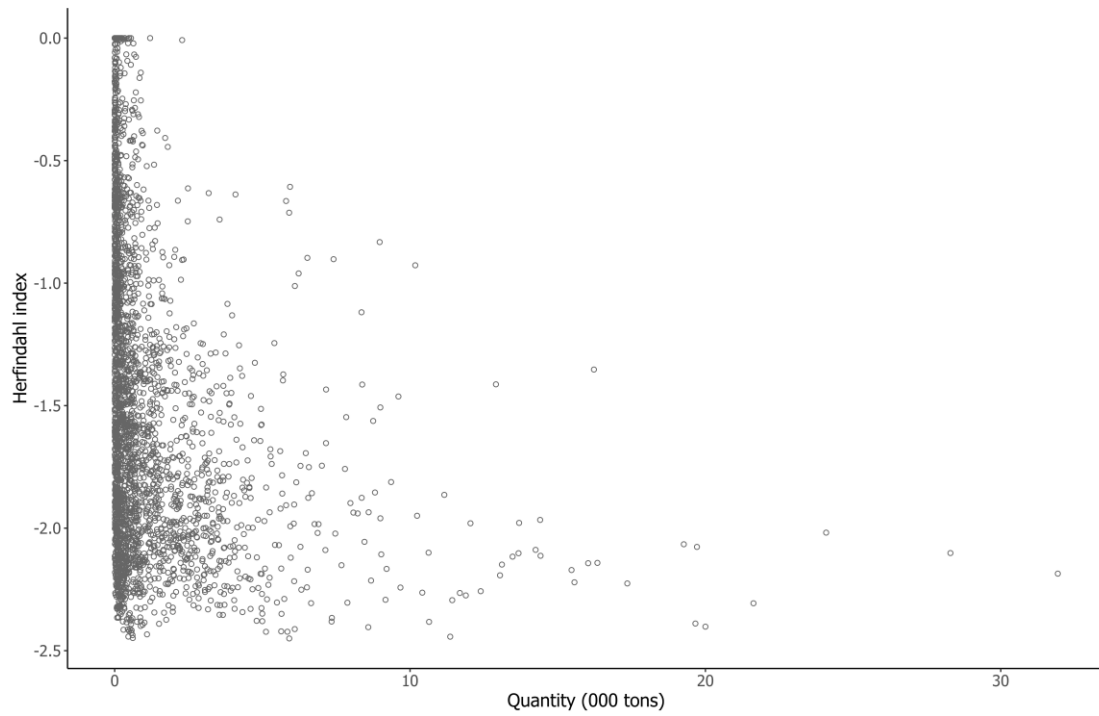


Figure 4: Concentration of landings over the year, by plant size

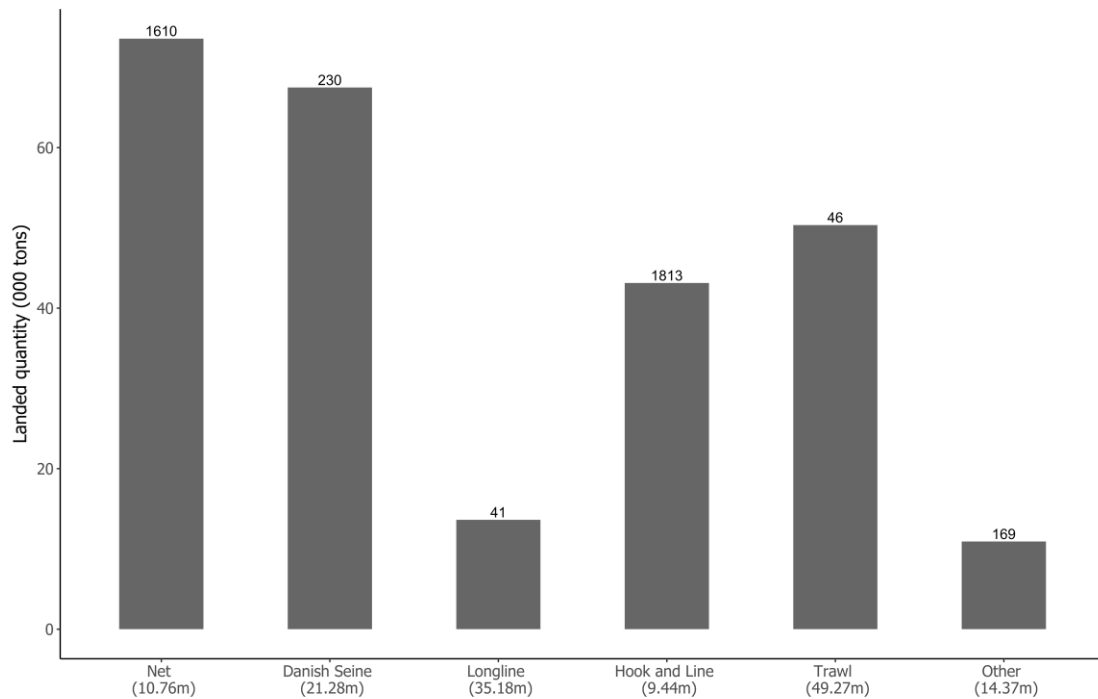


Figure 5: Average yearly landings by gear category (2002 - 2015). The average number of vessels in each category is indicated at the top of the bar plots, while each category also includes the average vessel length in meters.

There are other attributes that may play meaningful roles for a landing plant's continued operation, and that accordingly have been included in the analysis. A measure of a landing plant's attractiveness is the extent to which it is able to obtain landings from non-local vessels. Conversely, a high proportion of local vessels landing at the plant can be viewed as a measure of vessel loyalty. The landed quantity influences a landing plant's size and its opportunity to exploit economies of scale. The number of buyers, forming links in the supply chain, can be an indicator of a plant's attractiveness and of the competition for its output. Moreover, the number of additional landing plants within the same municipality is a measure of a possible industry cluster in that region. In addition to providing external economies of scale, industry clusters may be attractive to fishermen because they increase competition for their landings. Horizontal integration may also play a decisive role in a plant's survival due to the parent company's strategic influence over the different landing plants owned.⁶

Descriptive statistics for all variables used are presented in Table A1 in the Appendix.

The data are left truncated and right censored (LTRC). To address these issues, all observations of landing plants that only appeared in 2002 were removed from the sample due to the fact that the available dataset does not provide any information of when those plants first entered the market. Similarly, data for 2015 were used to find

⁶ Vertical integration may affect the survival of landing plants, since the decision of closing a particular plant is likely to depend on a larger multi-plant operating plan. However, data in this regard is not available and consequently, could not be incorporated into the analysis.

out if the landing plants active in 2014 remained active or exited the market after 2014.⁷ Hence, the estimation sample spans the period from 2002 to 2014.

3. METHODS

First, a pooled logit model is used to estimate the probability that a landing plant is exiting the industry. This model is then extended to a conditional logit (McFadden, 1974), where the response can be interpreted as the landing plants' decision to continue in business or to close down or exit. The conditional logit models introduce two sets of fixed effects (FE). The total allowable catch (TAC), which is set on a year-by-year basis, is likely to influence the landings of fish at all plants. In addition, some areas may increase their probability of remaining active, either because they are closer to the fishing grounds or due to better logistics. To control for all time-varying and location-varying factors that would influence a landing plant's activity, the model was run with both year fixed effects as well as with year-region fixed effects. The definition of region was aligned with the areas under Norges Råfisklag's control. To correct for the tendency of continuous variables toward right-skewedness, a log-transformation was applied.

⁷ About two thirds of the observations relate to plants that had been in the study since at least the first year of observation, creating a left-truncation challenge. A common approach used to address left-truncation is to remove those observations. This is not feasible when such a large portion of the data would have to be deleted. Alternatively, the nonparametric tree estimation method by Fu and Simonoff (2017) could be used if information on the age of each plant at entry in the study were available. As a robustness check, survival models with all these observations removed were run with an obvious loss in power. All variables previously significant remained relevant, to a large degree. These results have been provided in Table A2 in the Appendix.

Duration analysis (Wooldridge, 2010) is used to investigate factors that influence the length of any spell, and in this case how long a landing plant remains active. The survival function is defined as:

$$S(t) = \Pr(N \geq t),$$

where N measures the number of consecutive years a landing plant remains active. The survival function is non-parametrically estimated using a Kaplan-Meier filter. The hazard function, or the conditional failure rate, measuring the probability that a landing plant exits the industry after time t given that it has been in business up to time t , can be written as:

$$\delta(t) = \Pr(N = t | N \geq t).$$

The same attributes as in the (conditional) logit analysis were used as potential factors that influence the survival of landing plants. The hazard rates are estimated using the partial likelihood method proposed by Cox (1972):

$$h(t, \mathbf{x}, \boldsymbol{\beta}) = h_0(t)e^{\mathbf{x}\boldsymbol{\beta}},$$

where h_0 is the baseline hazard function at time t , while \mathbf{x} represents the vector of time-varying covariates. The Cox function allows the $\boldsymbol{\beta}$ parameters to be estimated without estimating the baseline hazard. The model is estimated with and without

region fixed effects. Moreover, re-entering plants were also accounted for in the analysis as multiple-spell dummies.⁸

4. EMPIRICAL RESULTS

The estimation results for the pooled logit (Model 1) and the conditional logit models (Model 2 and Model 3) are reported in Table 1.⁹ Across models, there is strong evidence in support of landings, landing plant clusters and seasonality playing a role in the survival of landing plants.

The coefficients on the landings variable are consistently negative and statistically significant, indicating that larger plants have a lower probability of exit. Robust standard errors are provided for the pooled logistic model (Model 1), and bootstrapped standard errors (Wooldridge, 2010; Cameron and Miller, 2015) are reported for models 2 and 3.¹⁰ Models 1 and 3 also indicate that the number of additional landing plants within the same municipality reduce the probability of exit, suggesting that there may be an industry cluster effect.¹¹ Plants that consistently receive landings from smaller vessels (under 15m) have a lower probability of exit.

⁸ The data do not provide the cause for a re-entry, and therefore a clear differentiation between what entails a new entry versus what qualifies as a re-entry is not possible.

⁹ The number of observations used in the analysis is adjusted when fixed effects are included, due to multiple positive or negative outcomes being encountered within groups.

¹⁰ The bootstrapping is conducted with 400 repetitions and seed=10101. In the tables, all corrected standard errors are referred to as *robust standard errors (se)*.

¹¹ To our knowledge, there exist no studies investigating industry clusters in fisheries. Tveteras (2002) and Asche, Tveteras and Roll (2016) provide evidence of industry clusters in the Norwegian aquaculture industry.

This is an indication that at least for some plants, the coastal fleet is important and that for these plants the smaller vessels support the community through the continued operation of the plant. It is interesting to note that being able to attract larger, more mobile vessels, or vessels from a variety of municipalities, does not influence the probability of exit. Receiving landings over a shorter period of time, not surprisingly, increases the chance of an exit. However, there is no specialization/diversification effect. Finally, the number of buyers being served by the plant and the existence of horizontal integration do not present an association with the probability of exit.

Estimation results for the four duration models are reported in Table 2. The reported parameters associated with each variable represent hazard ratios, calculated by exponentiating the estimated coefficients. Hence, a hazard ratio higher than one increases the probability of a failure, while one smaller than one reduces it. The significance level reported is therefore for the null hypothesis that the reported hazard ratio equals one. The downward sloping survival functions in Figure A2 suggest negative duration dependency.¹² That is, the longer the landing plant has been active, the lower the probability of it failing. Moreover, it is evident based on Figure A2 that only a small fraction of the firms fail after one year of operation. For both models 4 and 6 the 10-year survival rate is approximately 50%.

The results from the duration models indicate that all attributes that were originally found significant in the logit models remain significant, and in the expected

¹² Only duration models 4 and 6 are presented, for readability. When fixed effects are considered, the plots become more cumbersome as there is a function associated with each fixed effect, with no added value to the interpretation.

directions. For example, the hazard ratio for the number of additional landing plants in the same municipality is below one, implying that a lower number of landing plants in a municipality lead to an increased chance of failure. Hence, the empirical results appear robust relative to estimation procedure.

Table 1: Results from the pooled logit (Model 1) and the conditional logit models (Model 2 and Model 3), with robust standard errors and bootstrapped standard errors, respectively.

	Model 1			Model 2			Model 3		
	coeff	robust se(coeff)	dy/dx	coeff	robust se(coeff)	dy/dx	coeff	robust se(coeff)	dy/dx
ln(LANDED)	-0.1512***	0.0431	-0.0080	-0.1587***	0.0373	-0.0031	-0.1522***	0.0418	-0.0051
NVHOME	0.0261	0.0311	0.0014	0.0314	0.0336	0.0006	0.0386	0.0369	0.0013
NPLANT	-0.0320*	0.0180	-0.0017	-0.0226*	0.0137	-0.0004	-0.0548***	0.0184	-0.0018
NBUYER	0.0227	0.0188	0.0012	0.0186	0.0241	0.0004	0.0168	0.0232	0.0006
NU15	-0.0187**	0.0085	-0.0010	-0.0194**	0.0088	-0.0004	-0.0213***	0.0085	-0.0007
N15TO28	-0.0267	0.0232	-0.0014	-0.0255	0.0185	-0.0005	-0.0299	0.0262	-0.0010
NO28	-0.0632	0.0484	-0.0034	-0.0575	0.0474	-0.0011	-0.0480	0.0552	-0.0016
ln(HHISEASON)	1.0277***	0.1741	0.0686	1.0423***	0.1386	0.0254	0.9151***	0.1809	0.0401
ln(HHISPECIES)	-0.3186	0.2550	0.0109	-0.3661	0.2933	0.0031	-0.3193	0.3051	0.0079
ln(POP)	0.0332	0.0604	0.0018	0.0218	0.0650	0.0004	0.0827	0.0618	0.0028
HINTEG (=1)	-0.0460	0.1697	-0.0024	-0.0736	0.1098	-0.0014	-0.0480	0.1754	-0.0016
ln(HHISEASON)*ln(HHISPECIES)	-0.3700*	0.2045	-	-0.3755*	0.2249	-	-0.3990*	0.2280	-
N			2,924			2,725			2,465
Wald Chi2 (dof)			354.54 (12)			380.15 (12)			259.11 (12)
Year FE			No			Yes			No
Year-Region FE			No			No			Yes

* p<0.10, ** p<0.05, *** p<0.01

Table 2: Results from the survival models on the right-censored data

	M odel 4		M odel 5		M odel 6		M odel 7	
	hazard ratio exp(coef)	robust se(coef)	hazard ratio exp(coef)	robust se(coef)	hazard ratio exp(coef)	robust se(coef)	hazard ratio exp(coef)	robust se(coef)
ln(LANDED)	0.9036***	0.0285	0.9135***	0.0298	0.8857***	0.0273	0.8870***	0.0282
NVHOME	1.0234	0.0290	1.0264	0.0295	1.0210	0.0295	1.0203	0.0295
NPLANT	0.9728*	0.0150	0.9601**	0.0164	0.9780	0.0152	0.9663**	0.0170
NBUYER	1.0198	0.0179	1.0201	0.0188	1.0175	0.0177	1.0181	0.0186
NU15	0.9802***	0.0077	0.9788***	0.0078	0.9822**	0.0078	0.9817**	0.0077
N15TO28	0.9697	0.0221	0.9722	0.0240	0.9724	0.0224	0.9737	0.0236
NO28	0.9313*	0.0426	0.9341	0.0445	0.9507	0.0405	0.9541	0.0420
ln(HHISEASON)	2.4041***	0.1537	2.3520***	0.1578	2.2559***	0.1537	2.1380***	0.1557
ln(HHISPECIES)	0.7712	0.2012	0.7851	0.1975	0.6587**	0.2042	0.6402**	0.2084
ln(POP)	1.0325	0.0523	1.0385	0.0502	1.0311	0.0515	1.0512	0.0524
HINTEG (=1)	0.9695	0.1385	0.9926	0.1381	0.9130	0.1394	0.9401	0.1448
ln(HHISEASON)*ln(HHISPECIES)	0.6905**	0.1778	0.7018**	0.1723	0.6457**	0.1801	0.6213**	0.1799
Spell (re-entry after 2 years)	-	-	-	-	1.7020***	0.1586	1.5964***	0.1671
Spell (re-entry after 3 years)	-	-	-	-	2.0980***	0.2717	1.9319***	0.2821
Spell (re-entry after 4 years)	-	-	-	-	0.8298	0.6091	0.7859	0.6062
N		2,924		2,924		2,924		2,924
Wald test (dof)		383.8 (12)		332.7 (12)		488 (15)		505 (23)
Region FE		No		Yes		No		Yes

* p<0.10, ** p<0.05, *** p<0.01

5. CONCLUSIONS

Most of the attention in fisheries economics is given to what happens on the water. However, this is just the first step in the seafood supply chain. As demonstrated by Homans and Wilen (2005), which supply chain is served can have substantial impact on fishermen's income. More important for fisheries policy is that where the fish is landed strongly influences the impact of the industry in terms of jobs and economic activity in coastal communities. While it is well known that the number of fishermen and vessels are being rapidly reduced in many countries, little attention has been given to the reduction in number of landing spots and thereby their impact on coastal communities.

Norway is an example of such a country, where the number of fishermen as well as the number of landing plants are being reduced. Using data for the groundfish fisheries, this paper investigates if there are specific factors influencing which plants exit the industry. The results indicate that the size of a landing plant, as measured by total quantity landed, and landings from a fleet of smaller vessels, reduce a landing plant's probability of failure. In addition, stronger seasonality in landings increases the odds of exit by reducing capacity utilization at plants. Perhaps the most interesting result is that plants located in municipalities with additional landing spots have a lower probability of exit. This illustrates that industry clusters may be important. However, community size as measured by population count does not influence the survival probability, and there is accordingly no indication that the cluster benefits much from activities that are not fishery-related. Hence, there appears to be no reason for the cluster to move to the big city. It is also interesting that being able to attract vessels from other regions, or more mobile vessels, does not influence the probability of a landing plant's survival.

Overall the results suggest a bleak future for many vulnerable coastal communities. With most fisheries being fully or over-exploited (FAO, 2016), the only way some landing plants can increase landings is often through the disappearance of others. Extended fishing seasons will also contribute in this respect. This is, however, not an entirely bad outcome, as it provides job security for those who remain employed, not unlike what Abbott et al. (2010) report following a fisheries rationalization program that extended the fishing season. That the fisheries cluster seems to be independent of other industries also implies a way forward for fisheries-dependent coastal

communities that want to thrive. This requires policies that support the formation of clusters, maintain a coastal fleet, and support management changes that extend the fishing season.

REFERENCES

Abbott JK, Garber-Younts B, Wilen JE. Employment and Remuneration Effects of ITQs in the Bering/Aleutian Islands Crab Fisheries, *Marine Resource Economics* 2010; 25:333-354.

Abbott, J.K., Haynie, A.C. and Reimer, M.N., 2015. Hidden flexibility: institutions, incentives, and the margins of selectivity in fishing. *Land Economics*, 91(1):169-195.

Anderson, J.L., C.M. Anderson, J. Chu, J. Meredith, F. Asche, G. Sylvia, M.D. Smith, D. Anggraeni, R. Arthur, A. Guttormsen, J.K. McCluney, T. Ward, W. Akpalu, H. Eggert, J. Flores, M.A. Freeman, D.S. Holland, G. Knapp, M. Kobayashi, S. Larkin, K. MacLauchlin, K. Schnier, M. Soboil, S. Tveternas, H. Uchida, D. Valderrama. 2015. "The Fishery Performance Indicators: A Management Tool for Triple Bottom Line Outcomes." *PLOS ONE* 10(5).

Asche, F., Y. Chen, and M.D. Smith. 2015. "Economic incentives to target species and fish size: prices and fine-scale product attributes in Norwegian fisheries." *ICES Journal of Marine Science* 72(3):733-740.

Asche, F., K.H. Roll, and R. Tveternas. 2016. Profiting from agglomeration? Evidence from the salmon aquaculture industry." *Regional Studies* 50(10):1742-1754.

Blythe, J.L. 2015. "Resilience and social thresholds in small-scale fishing communities." *Sustainability Science* 10:157-165.

Bockstael, N.E., and J.J. Opaluch. 1983. "Discrete modelling of supply response under uncertainty: the case of the fishery." *Journal of Environmental Economics and Management* 10:125–137.

Cameron, A.C., and D.L. Miller. 2015. "A Practitioner's Guide to Cluster-Robust Inference." *The Journal of Human Resources* 50(2):317:372.

Copes, P., and A. Charles. 2004. "Socioeconomics of individual transferable quotas and community-based fishery management." *Agricultural and Resource Economics Review* 33(2):171-181.

Cox, D. 1972. "Regression Models and Life Tables." *Journal of the Royal Statistical Society. Series B* 34:187-220.

Eales, J., and J.E. Wilen. 1986. "An Examination of Fishing Location Choice in the Pink Shrimp Fishery." *Marine Resource Economics* 2(4):331-351.

Eggert, H., and R. Tveteras, 2004. "Stochastic Production and Heterogeneous Risk Preferences: Commercial Fishers' Gear Choices." *American Journal of Agricultural Economics* 86(1):199-212.

Food and Agriculture Organization (FAO). 2016. "Status of the world's fisheries and aquaculture." FAO: Rome.

Fu, W., and J.S. Simonoff. 2017. "Survival trees for left-truncated and right-censored data, with application to time-varying covariate data." *Biostatistics* 18(1):352-369.

Guttormsen, A.G., and K.H. Roll. 2011. "Technical Efficiency in a Heterogeneous Fishery." *Marine Resource Economics* 26(4):293-308.

Hannesson, R. 2013. "Norway's Experience with ITQs." *Marine Policy* 37:264-269.

Hannesson, R. 2017. "Return on Capital and Management Reforms in Norway's Fisheries." *Land Economics* 93(4):710-720.

Hannesson, R., K.G. Salvanes, and D. Squires. 2010. "Technological change and the tragedy of the commons: The Lofoten fishery over 130 years." *Land Economics* 86(4):746-765.

Hermansen, Ø., and B. Dreyer. 2010. "Challenging spatial and seasonal distribution of fish landings – The experience from rural community quotas in Norway." *Marine Policy* 34:567-574.

Hersoug, B. 2011. "Fishing rights to the right people?" *MAST* 10(2):15-39.

Homans, F.R., and J.E. Wilen, 2005. "Markets and rent dissipation in regulated open access fisheries." *Journal of Environmental Economics and Management* 49(2):381-404.

Huang, L., and M.D. Smith. 2014. "The dynamic efficiency costs of common-pool resource exploitation." *The American Economic Review* 104(12):4071-4103.

Kroetz K., J.N. Sanchirico, and D.K. Lew. 2015. "Efficiency Costs of Social Objectives in Tradable Permit Programs." *Journal of the Association of Environmental and Resource Economists* 2(3):339-366.

Kvamsdal, S.F. 2016. "Technical change as a stochastic trend in a fisheries model." *Marine Resource Economics* 31(4):403-419.

Matulich, S.C., R.C. Mittelhammer, and C. Reberte. 1996. "Toward a More Complete Model of Individual Transferable Fishing Quotas: Implications of Incorporating the Processing Sector." *Journal of Environmental Economics and Management* 31(1):112-128.

Matulich, S.C., and M. Sever. 1999. "Reconsidering the initial allocation of ITQs: The search for a Pareto-safe allocation between fishing and processing sectors." *Land Economics* 75(2): 203-219.

McFadden, D. 1974. "Conditional logit analysis of qualitative choice behavior. Frontiers in Econometrics." *P. Zarembka (Editor)*, New York, *Academic Press* 105-142.

Munk-Madsen, E. 1998. "The Norwegian fishing quota system: Another patriarchal

construction?” *Society and Natural Resources* 11(3):229-240.

National Marine Fisheries Service Alaska Regional Office (NOAA). Accessed 2017 July 06. “Community Development Quota (CDQ) Program.” <https://alaskafisheries.noaa.gov/fisheries/cdq>

North Pacific Fishery Management Council (NPFMC). Accessed 2017 July 06. “Development of Pacific Cod CDQ Small Vessel Fishery EA/RIR Public Review for Final Action 02/15.” *Council Motion* <https://www.npfmc.org/community-development-program/>

Olson, J. 2005. “Re-Placing the Space of Community: A Story of Clutural Politics, Policies, and Fisheries Management.” *Anthropological Quarterly* 78(1):247-268.

Olson, J. 2006. “Changing Property, Spatializing Difference: The Sea Scallop Fishery in New Bedford, Massachusetts.” *Society of Applied Anthropology* 65(3):307-318.

Pettersen, I.K., and Ø. Myrland. 2016. “A cod is a cod, but is it a commodity?” *Journal of Commodity Markets* 3(1):70-75.

Salvanes, K.G., and R. Tveteras. 2004. “Plant exit, vintage capital and the business cycle.” *The Journal of Industrial Economics* 52(2):255-276.

Smith, M.D., and J.E. Wilen. 2003. “Economic impacts of marine reserves: the importance of spatial behavior.” *Journal of Environmental Economics and*

Management 46(2): 183-206.

Standal, D., and B. Aarset. 2008. "The IVQ regime in Norway: A stable alternative to an ITQ regime?" *Marine Policy* 32(4):663-668.

Standal, D., and B. Hersoug. 2015. "Shaping technology, building society; the industrialization of the Norwegian cod fisheries." *Marine Policy* 51:66-74.

Standal, D., S.A. Sønvisen, and F. Asche. 2016. "Fishing in deep waters: The development of a deep-sea fishing coastal fleet in Norway." *Marine Policy* 63:1-7.

Statistics Norway (SSB). Accessed 2017 August 23. "Income and wealth statistics for households, 2015." <https://www.ssb.no/en/inntekt-og-forbruk/statistikker/ifhus>

Sumaila, U.R., V. Lam, F. Le Manach, W. Swartz, and D. Pauly. 2016. "Global Fisheries Subsidies: An Updated Estimate." *Marine Policy* 69:189-193.

Thompson, C., T. Johnson, and S. Hanes. 2016. "Vulnerability of fishing communities undergoing gentrification." *Journal of Rural Studies* 45:165-174.

Tietze, U. 2016. "Technical and socio-economic characteristics of small-scale fishing communities, and opportunities for poverty alleviation and empowerment." *FAO Fisheries and Aquaculture Circular No. 1111*.

Tull, M., S.J. Metcalf, and H. Gray. 2016. "The economic and social impacts of

environmental change on fishing towns and coastal communities: A historical case study of Geraldton, Western Australia.” *ICES journal of Marine Science* 73(5):1437-1446.

Tveteras, R. 2002. “Industrial agglomeration and production costs in Norwegian salmon aquaculture.” *Marine Resource Economics* 17(1):1-22.

Wooldridge, J.M., 2010. “Econometric analysis of cross section and panel data.” Second Edition. *The MIT Press*, Cambridge, Massachusetts.

APPENDIX

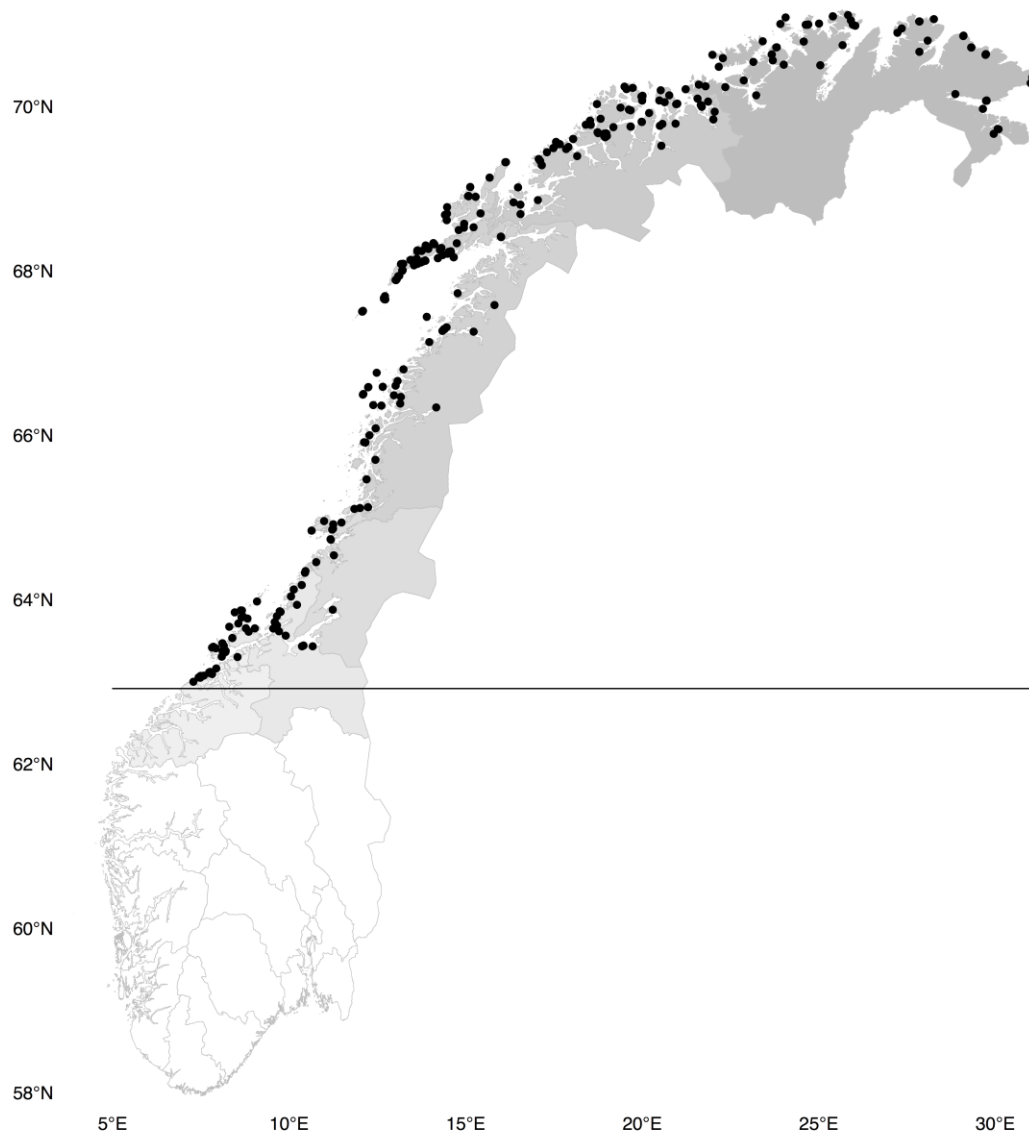


Figure A1: Map of Norway with counties managed by Norges Råfisklag in shades of gray, and with all landing plants under their jurisdiction over time, marked in black.

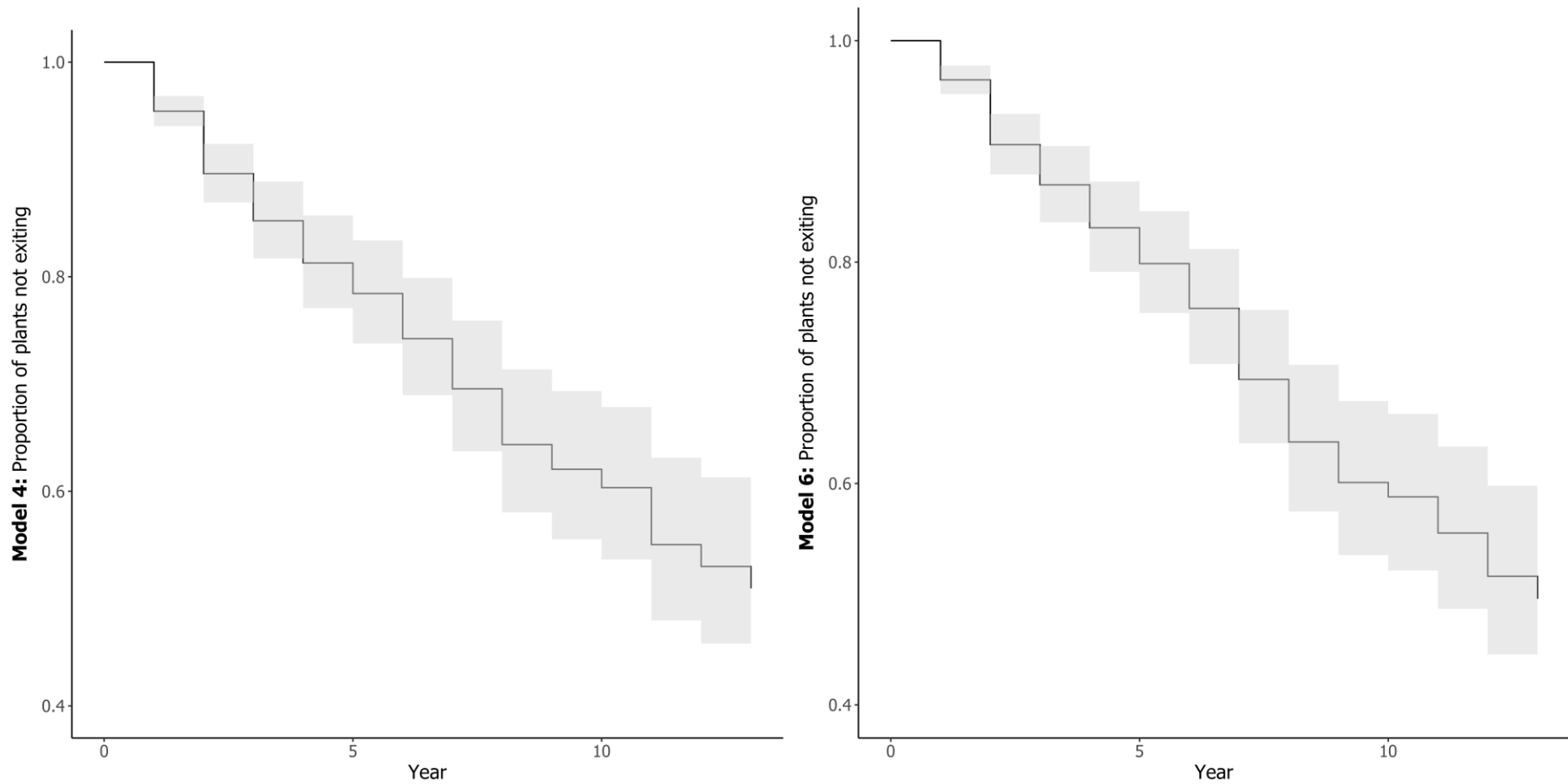


Figure A2: Estimated survival functions for models 4 and 6, with 95% confidence intervals included.

Table A1: Descriptive statistics

Variable	Description	Mean	Standard deviation	Min	Max
LANDED	Quantity landed (kg)	1,126,291	2,224,148	22	31,930,607
NVHOME	Number of home municipalities for vessels landing at that location	9.5722	11.1126	1	83
NPLANT	No. of additional plants within the same municipality	5.0212	4.0494	0	18
NBUYER	No. of associated fish buyers	2.5434	7.9667	1	90
NU15	No. of fishing vessels under 15 m	29.1648	34.8573	0	286
N15TO28	No. of fishing vessels between 15 and 28 m	5.0274	8.888	0	86
NO28	No. of fishing vessels over 28 m	1.1279	3.647	0	47
HHISEASON	HHI seasonality	0.3148	0.2587	0.0863	1
HHISPECIES	HHI species	0.5467	0.2489	0.1176	1
POP	Population count in home municipality	9,268	18,321	444	182,035
H_INTEG	Horizontal integration indicator			0: 1,672	1: 1,252

Table A2: Results from the survival models on the LTRC data

	Model 4*		Model 5*		Model 6*		Model 7*	
	hazard ratio <i>exp(coef)</i>	robust se(coef)	hazard ratio <i>exp(coef)</i>	robust se(coef)	hazard ratio <i>exp(coef)</i>	robust se(coef)	hazard ratio <i>exp(coef)</i>	robust se(coef)
ln(LANDED)	0.9741	0.0373	0.9789	0.0423	0.9618	0.0351	0.9705	0.0404
NVHOME	1.0686	0.0486	1.0926*	0.0515	1.0634	0.0512	1.0897	0.0531
NPLANT	0.9730	0.0198	0.9555**	0.0224	0.9760	0.0201	0.9603*	0.0228
NBUYER	0.9973	0.0282	0.9948	0.0349	0.9970	0.0269	0.9959	0.0333
NU15	0.9687**	0.0143	0.9657**	0.0158	0.9709**	0.0149	0.9657**	0.0161
N15TO28	0.9515	0.0397	0.9410	0.0441	0.9526	0.0410	0.9471	0.0429
NO28	0.9090	0.0845	0.9011	0.1135	0.9207	0.0796	0.8948	0.1119
ln(HHISEASON)	2.3700***	0.1967	2.0522***	0.2064	2.3133***	0.1963	2.0648***	0.2060
ln(HHISPECIES)	1.0867	0.2895	1.1092	0.2800	1.0215	0.2955	1.0751	0.2839
ln(POP)	1.0426	0.0689	1.0321	0.0632	1.0312	0.0683	1.0290	0.0636
HINTEG (=1)	0.6352**	0.2286	0.7103	0.2386	0.6110**	0.2361	0.6948	0.2481
ln(HHISEASON)*ln(HHISPECIES)	0.7892	0.2436	0.6856	0.2373	0.7939	0.2004	0.7061	0.2371
Spell (re-entry after 2 years)	-	-	-	-	1.5579**	0.3222	1.2499	0.2079
Spell (re-entry after 3 years)	-	-	-	-	2.9152***	0.2450	2.0502**	0.3155
N		945		945		945		945
Wald test (dof)		140.4 (12)		107.5 (12)		161.2 (14)		117.3 (14)
Region FE		No		Yes		No		Yes

* p<0.10, ** p<0.05, *** p<0.01