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Consolidation and distribution of quota holdings in the Icelandic fisheries

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ABSTRACT

The aim of this work is to measure the development of the concentration of quota holdings by harvesting companies and harbours in Iceland. For the period 1990–2014, the analysis traces the development of relative quota holdings of the biggest actors operating large vessels as well as firms that employ smaller boats that are only allowed to use hook-and-line. A more detailed data set is used for the period 2001–2014 which allows for a more thorough investigation of consolidation in both fleet segments using Herfindahl-Hirchman Indexes, Gini coefficients and Lorenz-curves. The biggest firms in the two fleet segments increased their share of quotas throughout the period but the quota market is though still quite competitive. The distribution of quotas between firms has become more unequal, and there is also clear evidence of increasing transfers between harbours, especially in the case of the quota shares of hook-and-line boats. However, the results also indicate that spatial concentration has been much less than consolidation at firm level during the period under consideration. This would indicate that firms have mostly grown in size by merging with local firms or buying out smaller local operators.

1. Introduction

In the last 40 years rights-based management regimes, including individually transferable quotas (ITQs), in fisheries have become ever more prominent. A recent estimate puts the number of such programs at 647 [1], representing about 25% of global fish landings [2]. Economic theory teaches that introducing ITQs into an overcapitalised fishery will bring about considerable efficiency gains [3], not least through the reduction of fishing capacity as more efficient operators will buy out those less efficient. This is indeed borne out by experience [4,5]. For instance, studies on the Alaskan Pacific halibut and sable fisheries [6], the British Columbia halibut fishery [7,8], the Scotia-Fundy groundfish fishery [9–11], the Mid-Atlantic surf clam and ocean quahog fishery [12], the New Zealand Quota Management System [13,14], the Norwegian pelagic and cod fisheries [15], the Tasmanian red rock lobster fishery [16], the Great Barrier Reef fin-fish fishery [17] and the Icelandic fisheries [18–21,22] all reveal how fishing fleets shrank after individual vessel quotas were implemented and made transferable.

In the industrial organisation literature, various measures have been utilised for the analysis of market structure [23]. Some of these measures have also been employed to study consolidation in the fishing industries. These include the application of simple concentration ratios (CR) [18,19,21,24] as well as the Herfindahl-Hirschman Index (HHI) to measure market concentration [14,24–27]. Other inquiries have made use of so-called Lorenz curves and their numerical equivalent, the Gini-coefficient, which are frequently used in studies of the distribution of income and wealth. Palsson and Helgason [18] apply this approach to study consolidation in the Icelandic fisheries 1984–1994, Liew [10] to analyse concentration in Canada's Scotia-Fundy inshore groundfish fishery 1990–1998 and Connor [25] to examine consolidation in the inshore, mid-depth and deep-water fisheries in New Zealand during 1987–1998. More recently, Abayomi and Yandle [14] have employed conditional Gini coefficients and conditional Lorenz curves to study changes in ownership from the start of the ITQs in 1987–1990 to 2007–2009. Gini coefficients have also been used to analyse consolidation in the red snapper fishery in the gulf of Mexico [26].

As one of the first countries to introduce individual transferable quotas in the 1970 s and 1980s, Iceland has over 30 years of experience with management systems based on property rights. Individual vessel quotas (IQs) were first imposed on the pelagic fisheries and then in 1984 on the main demersal fisheries [28,29]. By 1988, a system of ITQs was in effect for all fisheries, although an effort quota option was still retained in the demersal fisheries. Since 1990, a comprehensive ITQ-system has been in effect for all vessels larger than 6 gross registered tonnes (GRT). Smaller boats

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were managed by a complex set of rules and regulations until the early 2000s, when this intricate management web was phased out and the small boats were incorporated into the ITQ regime [30].[1] The small boats are only allowed to use hand-line and longline, but no such restrictions apply to larger vessels. Quota transfers from boats operating only hand-line and longline to larger ones are prohibited, but transfers in the reverse direction are not. Therefore, to a degree, these two fleet segments may be seen as operating under separate quota systems.

In this paper, consolidation in the two fleet-segments of the Icelandic harvesting sector is analysed using all three methods outlined earlier; concentration ratios, HHI and Lorenz curves and the associated Gini coefficients. Discussion first centres on the development of relative quota holdings of the largest harvesting companies in each fleet-segment during 1991–2014. For the larger vessels, this covers the period since the comprehensive ITQ-system came into effect in 1990 while for the smaller boats the study covers the period since that fleet segment was included in the ITQ-system in 2001. This is followed by a more thorough analysis of the consolidation that has occurred, based on the calculation of HHI and construction of Lorenz curves and the associated Gini coefficients. The data set used for this purpose only covers the period 2001–2014, but is more detailed and allows both for a study of changes in the distribution of quota holdings between individual firms as well as between communities. As before, the development in each fleet-segment is studied separately. The spatial dimension makes it possible to determine whether the largest firms have grown by buying quotas from operators all over the country, or whether consolidation has mainly occurred at a local level, leaving the distribution of quotas between communities (districts) relatively unchanged.

2. The Icelandic ITQ system

Since 1990, management of the Icelandic fisheries has been based on the Fisheries Management Act and its subsequent amendments [31]. At present, the ITQ system applies to fisheries for various species that together make up 98% of landed value [30]. Quotas are assigned to individual vessels but are transferable. Initial quota allocations were based on previous fishing history, but quota holdings have since changed as a result of quota transactions, with many of the original holders no longer active. The management system distinguishes between two kinds of quota in each fishery: quota shares and harvest rights. The former are sometimes called “permanent quotas” and the latter “annual catch entitlements” or “catch shares”. Quota shares quantify the holder’s entitlement to a percentage of each year’s total allowable catch (TAC) in each fishery. A vessel may, for instance, hold a 1% share in the cod fishery. Once the TAC has been set, the harvest rights for the fishery in question are simply calculated as the product of the vessel’s quota share and TAC. Each summer, based on available data and stock assessments, the governmental Marine Research Institute (MRI) publishes its advice on how large the TAC should be for each species in the ensuing fishing year (September-August). While the Minister of Fisheries does have powers to deviate from these recommendations, it has in recent years adhered, for the most part, to MRI’s advice. The precautionary approach taken by MRI has generally been quite successful, notably for cod, Iceland’s most important fishery, where the stock has rebounded in recent years and is now considerably larger than in 1990 [32].

Currently, there are two different types of general fishing permits, general fishing permit with a catch quota and a general fishing permit with a hook-and-line quota. In what follows the former are called regular quotas and the latter hook-and-line quotas. Hook-and-line quotas may only be utilised by boats smaller than 30 GRT that only use hand-line or longline. Both quota shares and harvest rights are transferable between vessels within each size category. Transfers from regular quota vessels to hook-and-line vessels are allowed but quotas may not be transferred from boats holding hook-and-line quotas to vessels holding regular quotas. Quota shares are perfectly divisible and may be transferred wholly or in part, provided that the transfer does not result in the quota share of the receiving vessel obviously exceeding its fishing capacity. In the case of vessel sales, municipal authorities have first refusal on vessels holding quotas that are to be sold to operators in a different municipality. This provision has very rarely been exercised. The combined quota shares of fishing vessels held by individual parties in each fishery may not exceed a certain maximum, which is 12% of the total quota shares in the case of cod, but 20% for haddock, saithe, Greenland halibut, herring, capelin and deep-water shrimp, and 35% for redfish. Maximum holdings are much smaller for vessels with hook-and-line quotas: 4% of the total quotas allocated to vessels in this category in the case of cod and 5% for haddock. Quotas of different species may be added together in tons or kg. using cod equivalents. These are defined in the Fisheries Management Act as the unit value of each species relative to the unit value of cod, the most important fishery. The cod equivalents are calculated for each fishing year on the basis of the average unit value of the landings of each species during the previous May-April period. For vessels operating under the regular quota system, the combined share in all fisheries may not exceed 12% in cod equivalents, but the corresponding maximum for hook-and-line boats is 5%. While harvest rights are also perfectly divisible, vessels must utilise at least half of their harvest rights each fishing year or else forfeit their quota shares. This applies to both hook-and-line boats as well as to larger ships.

When the comprehensive ITQ system was introduced in 1990, it only applied to vessels larger than 6 GRT. Smaller vessels could choose between entering the quota system or remaining outside the quota system. Almost all vessel owners opted for the latter. During the next decade, many different kinds of effort restrictions were used to limit the catches of these “outsiders”, although the drawbacks of continuing to use effort restrictions were plain to see [30]. Finally, in 1999, operators of these small boats were given a choice between effort restrictions with transferable fishing days and a quota system that came into effect in the fishing year 2001/2002. Over the next few years, the effort restrictions were slowly phased out. The number of boats still under the effort restriction system shrank from 219 at the beginning of the fishing year 2001/2002 to 14 in 2004/2005, with the last two boats entering the quota system two years later.

In 2009, a new coastal fishery was set up in order to open up possibilities for new entrants and increase flexibility. All registered boats, including those holding quotas, may join the fishery which runs during May, June, July and August. The fishing grounds off Iceland are divided into four areas and a pre-determined cod-cap set for each month in each of the areas. The fishery is an open-access fishery and fishing in each month and area is suspended once the cap is reached. Boats may only employ hand-line and can only fish for 14 h per day during Monday-Thursday. While popular in some quarters, the coastal fishery fits badly into the overall management system which has grown away from the derby-style fisheries of old.

[1] In the summer of 2009, a new small open-access fishery with a cod-cap opened up for boats operating hook-and-line. This is discussed in more detail in Section 2.

3. Methodology

Concentration ratios are calculated by simply adding together the quota shares of a pre-determined number of firms. A five firm concentration ratio will thus show the combined quota share of the five largest firms, but will not consider how the quota is shared within this group of firms. This drawback can though be overcome by calculating several concentration ratios of different sizes. In this study, calculations are done on the quota share of the largest firm, and the 5, 10 and 25 largest firm in each fleet-segment at the beginning of each fishing year.

Another way of addressing this problem is to measure competiveness by computing the Herfindahl-Hirschman Index (HHI) [33,34] for market concentration. This index is calculated by summing up the squared quota shares of the firms in question. This index is defined as

$$HHI = \sum_{i=1}^{N} s_i^2 \tag{1}$$

where s_i represents the combined quota share of firm i in all fisheries and N is the number of firms included. HHI looks therefore more closely at the distribution of quota and the relative size of each harvester. HHI may be presented in shares, in which case the index will take a value between 0 and 1, or as percentages in which case the index ranges from 0 to 10,000. The latter representation is similar to the Simpson index [35] used in ecology. In the case of a complete monopoly, HHI takes a value of 1 (10,000), whereas a value below 0.1 (1000) indicates low concentration. In fisheries, HHI indexed have both been applied to studies of quota consolidation [14,24–27] as well as to estimates of income diversification [36]. According to horizontal mergers guidelines issued by the European Commission (EC), a HHI below 1000 does not constitute grounds for competition concerns [37].

Note that if an industry is populated by firms of equal size, then the inverse of the HHI-index for that industry is equal to the number of firms in the industry. Hence, had the regular quota fleet been populated by firms of equal size there would have been 39 firms in the fishing year 2001/2002 and 23 in the fishing year 2014/2015, a 41% decrease. Similarly, had the hook-and-line quota fleet been populated by firms of equal size, they would have numbered 222 in 2001/2002 and 55 in 2014/2015 or a 75% decrease.

Lorenz curve were developed by Lorenz [38] to measure concentration of wealth but have since been used in numerous studies on wealth and income distribution, as well as to estimate changes in harvest quota holdings [10,14,18,25,26].

There are several ways to construct Lorenz curves and calculate the associated Gini index. A basic method is simply to arrange the data to be analysed in rank order, and write the observations as y_1, y_2, …, y_n, so that y_1 is the smallest income and y_n the highest. For the Lorenz-curve, the horizontal scale on the figure is marked into n equal intervals, say deciles, with the first interval representing the 10% of the population with the lowest income and the last interval the 10% with the highest income. The cumulative share of income is then shown on the vertical axis of the figure. In a perfectly egalitarian world, all individuals would hold an equal income share, as represented by the 45° line in Fig. 1. The dotted line in Fig. 1 shows a less equal distribution that is skewed towards the more affluent individuals.

The Gini-index was proposed by Gini [39] as a numerical index which was defined as "the mean difference from all observed quantities" [40]. The index may be expressed in terms of Lorenz curves, as the area between the line of perfect equality in Fig. 1 and the curve representing unequal distribution (area A) divided by the total area under the line of perfect equality (area A+B). Thus,

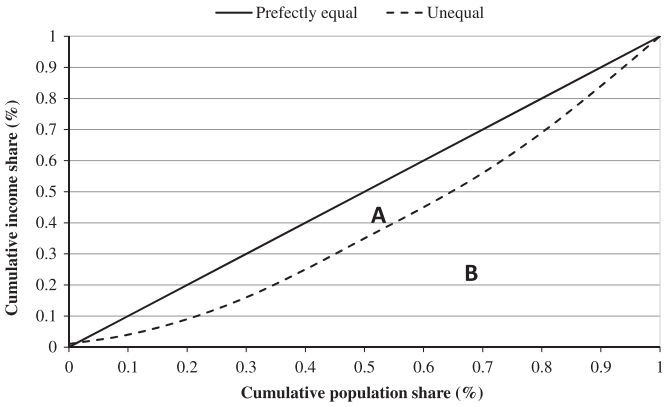

Fig. 1. Lorenz curves.

the Gini coefficient is size of area A in relation to the combined size of areas A and B or Gini=A/(A+B). In the case of perfect equality, the Gini index takes a value of zero (as area A has shrunk to zero), while in the case of perfect inequality, i.e. where one individual would hold all income in society, the Gini index takes a value of unity (as the area B has shrunk to zero).

Provided $y_k < y_{k+1}$, the Gini index may be calculated using the formula [41]

$$Gini = \frac{1}{n}\left(n + 1 - 2\frac{\sum_{k=1}^{n}(n+1-k)y_k}{\sum_{k=1}^{n} y_k}\right). \tag{2}$$

Here, n refers to the total number of observations in the time period, typically a year, while y is the variable under consideration, in this case quota holdings.

The Gini coefficient is a relative measure which only gives a point-estimate of equality at a certain moment of time. Two quite different income distributions may also yield the same Gini coefficient.

4. Data

The quota system that came into effect in 1990 was, to a large extent, based on the quota system initiated in the main demersal fisheries in 1984. However, during the years 1985–1990, the demersal fisheries were managed by a hybrid system of effort restriction and quotas. Vessels operating under effort restrictions could thus gain an additional quota, and special rules also applied to vessels that had been out of operation during the reference period on which initial quota allocations were based, as well as vessels that changed hands or where a new captain had taken over the ship. Transfers of quotas in the main demersal fisheries were also not allowed until 1988 [42,43]. For these reasons, it makes more sense to base the analysis only on the period after 1990, when the current ITQ system came into effect, rather than stretch it back into earlier years.

The data used in this analysis is supplied by the Icelandic Directory of Fisheries (DoF), a government agency charged with the task of monitoring fisheries and the daily administration of the fisheries management system. The data covers the period 1990–2014, which corresponds to the time the comprehensive ITQ-system has been in operation, and includes quotas of the following species: cod, haddock, saithe, redfish, golden redfish, ling, blue ling, tusk, wolffish, monkfish, greater silver smelt, Greenland halibut, plaice, witch, lemon sole, dab, herring, lobster, inshore and offshore shrimp, Norway redfish and demersal deep-sea redfish. Quotas for some of these species were though not issued in all

years. For the period 1990–2001 information is only available on quota holdings of the 25 largest harvesting companies, but for the period after that data can be found on quota holdings of all harvesting companies, both those operating vessels with regular quotas and those operating hook-and-line boats.

As noted by Palsson and Helgason [18], Lorenz curves and Gini coefficients are mainly designed to gauge distributions among relatively constant populations of individuals where distributional changes result from the movement of wealth, but not people. Therefore, when this methodology is used to analyse changes in quota holdings, there is a risk that the inequality resulting from quota sellouts will be underestimated, "since fewer ITQ-holders generally means that less needs to be redistributed in order to attain perfect equality". To counter this, Palsson and Helgason [18] recommend including drop-outs, the so-called "null components". This advice is heeded here. The panel data used thus includes observations on firms that have sold all their quotas in previous years. To take an example, a firm that holds quotas in the fishing years 2001/2002–2005/2006 but then sells out completely and does not reinvest in quotas during the rest of the period under observation, is included in the data with quota holdings of zero set for the fishing years after 2005/2006. While this approach is appropriate if the owners of the selling firm leave the fisheries business altogether, it may be more questionable if those selling quotas have merged or been taken over by other firms but still remain in partial ownership of a harvesting company. However, the bias from including only firms with positive quota holdings is probably greater than the bias from including all firms which have sold their quotas, as mergers or takeovers have probably been less common than sellouts and exits from the industry.

In addition to data on the quota allocation of individual vessels and thus firms, DoF also publishes data on the amount of quotas assigned to vessels registered in each harbour by ship categories, i.e. trawlers, other large and small vessels, and hook-and-line boats. This makes it possible to analyse the spatial distribution of quota holdings over the period 2001–2014. The harbour data also include the above-mentioned "null components". As all the harbours in the dataset are located in separate communities, the words harbour and community are used interchangeably in what follows. More than one community may, however, belong to the same municipality.

The DoF data contain information on the total harvest rights assigned to each firm or harbour at the beginning of each fishing year, i.e. the combined harvest rights allocated in each fishery. The total allocation is denominated in cod equivalents. In this paper, the quota shares are then calculated as the share of each operator or harbour of the combined quota allocation in all fisheries, measured in cod equivalents.

5. Results

In this section, attention is first paid to how the relative quota shares of the largest harvesting companies have evolved over the period 1990–2014, and then to measures of consolidation based on HHI, Lorenz curves and Gini coefficients for the period 2001–2014.

At the start of the 1990/1991 fishing year, the largest harvesting company held 4.3% of the total quota allocations within the regular quota system, measured in cod equivalents. Ten years later, the quota share of the largest firm had risen to 5.7% and at the start of the 2014/2015 fishing year, its share amounted to 10.7%. The share of the 5 largest firms had over the same 24-year period risen from 14% to 31.5%; the share of the 10 largest had more than doubled from 21.9% to 50.5%; and the share of the 25 largest had increased from 39.2% to 74.4%. A similar development, if not quite as pronounced, has occurred among vessels holding hook-and-line

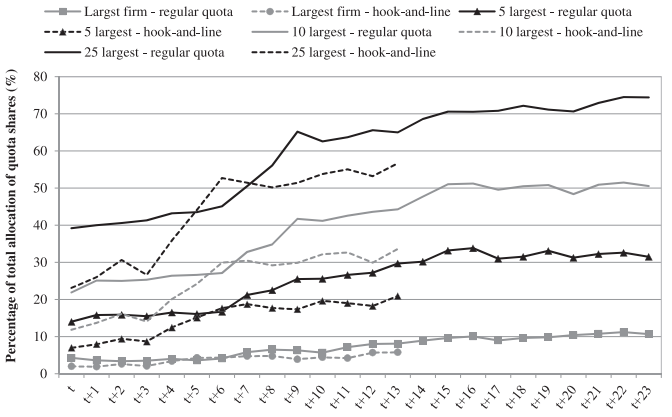

Fig. 2. Quota consolidation among harvesting companies operating vessels with regular quotas and hook-and-line quotas. Source: Directorate of Fisheries.

quotas. Here, the share of the largest firm has almost trebled from 2% to 5.8% over the 2001/2002 to 2014/2015 period, while the share of the 5 largest companies has risen from 7% to 20.9%, the share of the 10 largest from 11.8% to 33.6%, and the share of the 25 largest from 23.1% to 56.7%. These developments are traced in Fig. 2, where time *t* refers to the year when the quota system was introduced. Thus, in the case of vessels with regular quotas, *t* corresponds to the 1990/1991 fishing year, while in the case of vessels with hook-and-line quotas, *t* refers to the 2001/2002 fishing year.

Three things stand out. First, the quota holdings of harvesting companies in year *t* are always larger for firms operating vessels with regular quotas than for firms operating boats with hook-and-line quotas. Second, consolidation is much faster in the first years in the hook-and-line system. Indeed, after six years, quota ownership has always become more concentrated among those operating hook-and-line boats. Third, consolidation appears to stop or only increase marginally after about 10 years for hook-and-line boats, but after about 15 years for larger vessels.

Estimates of market concentration using the HHI are presented in Table 1. For harvesting companies holding regular quotas, the index takes values ranging from 265 observed in the fishing year 2001/2002 to 452 observed in the fishing year 2013/2014. The results for firms operating vessels with hook-and-line quotas are also quite low. The HHI value is 45 in the fishing year 2001/2002 but 183 in the fishing year 2014/2015.

As discussed above, HHI values of less than 1000 indicate low market concentration. The HHI values obtained here are much lower, and thus indicate that the market for quota shares is competitive. This is hardly surprising, given that there are quota

Table 1
Market concentration in the Icelandic fisheries 2001–2014 as measured by the Herfindahl-Hirschman Index. Source: Directorate of Fisheries.

Fishing year	Regular license	Hook-and-line license
2001/2002	256	45
2002/2003	264	51
2003/2004	288	64
2004/2005	305	49
2005/2006	349	79
2006/2007	357	111
2007/2008	407	151
2008/2009	375	153
2009/2010	396	145
2010/2011	442	149
2011/2012	424	164
2012/2013	445	167
2013/2014	452	162
2014/2015	432	183

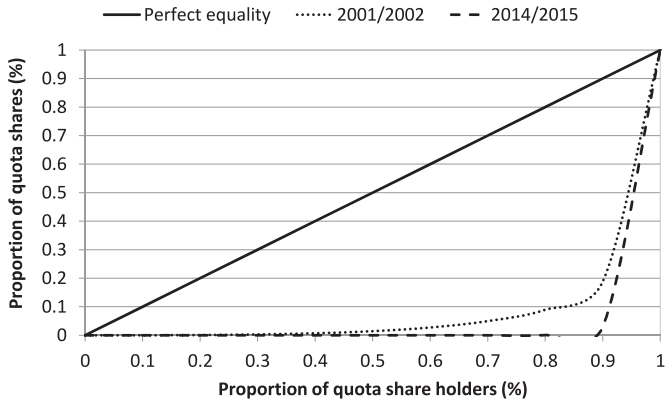

Fig. 3. Lorenz curves for harvesting companies operating vessels with regular quotas. Source: Directorate of Fisheries.

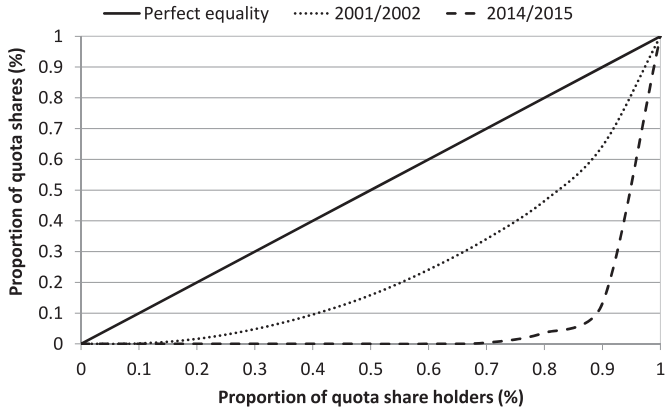

Fig. 4. Lorenz curves for harvesting companies operating vessels with hook-and-line quotas. Source: Directorate of Fisheries.

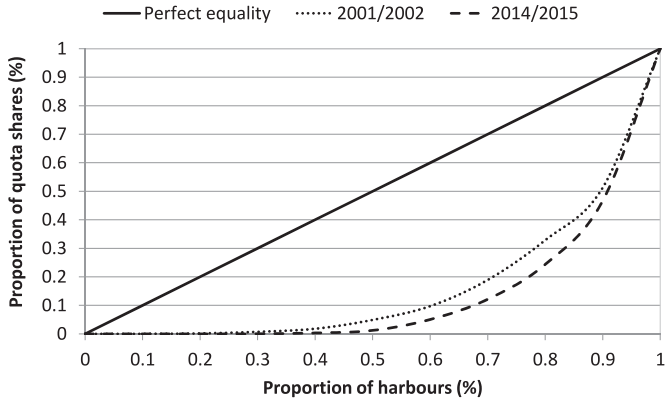

Fig. 5. Lorenz curves for vessels with regular quotas registered in different harbours. Source: Directorate of Fisheries.

ceilings in place for both fleet segments. However, although relatively small, the HHI values have increased over the period under study; by two thirds for the larger vessels and more than three times for the hook-and-line boats.

In Fig. 3 estimates are presented of Lorenz curves for harvesting shares for companies that operate vessels with regular quotas. The horizontal axis represents holders of quota shares arrayed in deciles of ascending order, with the first decile being equivalent to the smallest 10% of shareholders and the tenth decile equivalent to the largest 10%. The vertical axis shows the proportion of quota shares. Perfect equality is represented by the 45° line, while the

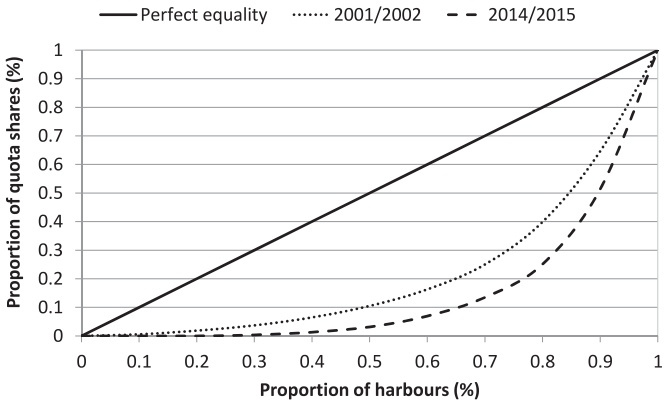

Fig. 6. Lorenz curves for vessels with hook-and-line quotas registered in different harbours. Source: Directorate of Fisheries.

two dotted lines show the distribution of quota shares at the beginning of the 2001/2002 and 2014/2015 fishing years. The latter is slightly to the right of the former, indicating that the distribution of quota holdings has become more unequal during this period. This is confirmed through the Gini coefficient which takes a value of 0.870 in the 2001/2002 fishing year but measured 0.957 in 2014/2015.

Results for the boats with hook-and-line quotas are presented in Fig. 4. The Lorenz curve shows a large shift to the right, with the increased inequality spread across all deciles. The difference is substantial and the shift of the Lorenz curve is much more pronounced in the hook-and-line system than in the regular system. At the beginning of the 2001/2002 fishing year, for instance, the lower 50% of quota owners held a combined 15.9% quota share, but by the 2014/2015 fishing year, this share had dwindled to zero At the same time, the holdings of the largest decile had increased from 36% to 86%. The Gini coefficient measured 0.513 in 2001/2002 but had risen to 0.909 in 2014/2015.

Whereas quota transactions can lead to increased concentration of quota ownership, they need not affect the regional distribution of quotas if the consolidation takes place at a local level. To examine this point further, the level of spatial concentration is analysed using Lorenz curves and Gini coefficients for the distribution of quota shares held by vessels registered in each harbour. The results for the vessels holding regular quotas are presented in Fig. 5. The Lorenz curves reveal how quota distribution had become less equal in the fishing year 2014/2015 than it was in the fishing year 2001/2002. The Gini coefficient is 0.696 in 2001/2002 and 0.735 in 2014/2015.

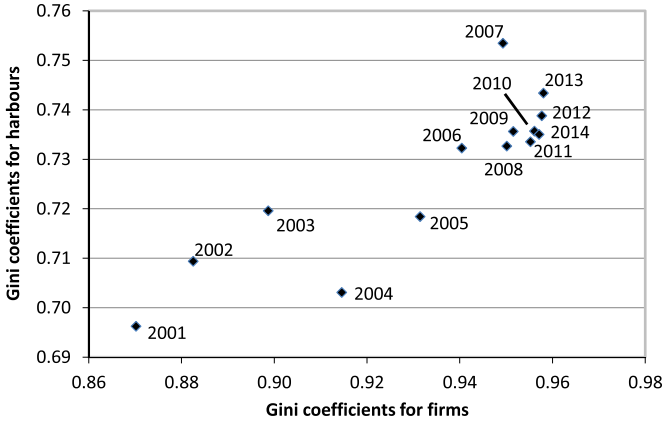

Fig. 7. Gini coefficients for firms and harbours operating vessels with regular quotas. Source: Directorate of Fisheries.

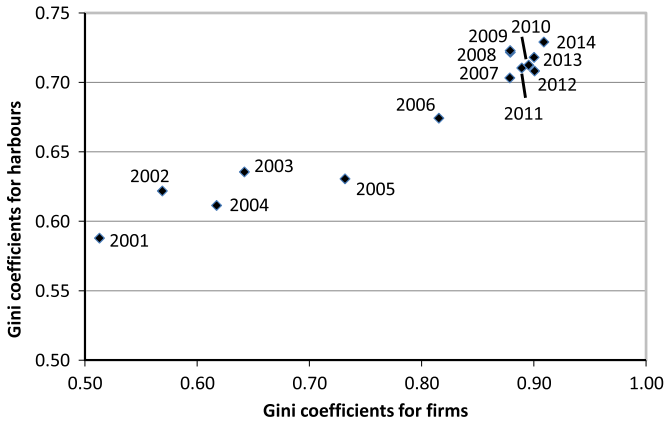

Fig. 8. Gini coefficients for firms and harbours operating vessels with hook-and-line quotas. Source: Directorate of Fisheries.

A similar picture emerges from analysing the spatial distribution of harvesting shares of vessels with hook-and-line quotas, as shown in Fig. 6. Here, the distribution of quotas between harbours has become considerably more unequal. This is well reflected in the Gini coefficient, which increased from 0.588 in the 2001/2002 fishing year to 0.729 in the 2014/2015 fishing year. The largest changes here occurred in the years 2005–2008 when the estimated Gini coefficient increased from 0.611 to 0.722. To a substantial degree this is due to the fact that the share of the largest harbour increased from 13.5% to 19.7% between the fishing years 2005/2006 and 2008/2009. The total allowable catch of cod was reduced from 198 thousand tonnes in the fishing year 2005/2006 to just 130 thousand tonnes two years later and remained quite low the next three years. It was not until 2012/2013 that the TAC was back to 195 thousand tonnes. This reduction in catches appears to have hit some of the smaller harbours particularly bad as the combined quota share of the 50% of the harbours holding the least quota decreased from 10.4% to 4.7%.

In order to examine further these two dimensions of quota concentration, it is useful to put together in a single diagram the pair of Gini coefficients calculated for each fleet segment. Figs. 7 and 8 thus have the calculated Gini coefficients for firms on the horizontal axis and the corresponding Gini coefficients for harbours on the vertical axis.

As shown in Fig. 7, both firm-level and spatial consolidation increased quite fast in the years 2001/2002 to 2007/2008 for vessels with regular quotas, but has since remained roughly the same. Observations for the former period reveal a clear positive relationship between the two Gini measures, while those for the later period are clustered in the upper right hand corner of the figure.

A similar development is observed for vessels with hook-and-line quotas. Concentration within both dimensions increased quite rapidly between the 2001/2002 and 2007/2008 fishing years, but has since remained almost constant, as shown in Fig. 8.

As mentioned above, harvesting companies operating vessels in the regular quota system may not hold more than 12% of the total allotted quota in all species, in cod equivalents, and boats holding hook-and-line quotas may not hold more than 5%. While the largest firm holding regular quotas has so far been below this maximum, the largest hook-and-line harvesting company was slightly above the ceiling at the start of the 2013/2014 and 2014/2015 fishing years. The Fisheries Management Act contains a special provision that concerns hook-and-line firms whose quota holdings exceeded the quota ceiling when this provision of the Act came into effect. These firms were given until September 1st 2016 to adjust their quota holdings so that they would meet these legal requirements. The firm in question has now sold off part of its quota.

6. Discussion

All the measures employed indicate that considerable quota consolidation has occurred in the Icelandic fisheries. The share of the largest firm holding regular quotas increased from 4.3% at the beginning of the fishing year 2001/2002 to 10.7% at the beginning of the year 204/2015, while the share of the 25 largest firms increased from 39% to 74% over the same period. The largest boat holding hook-and-line quotas held a 2.0% share in 2001/2002, but by 2014/2015 this share had almost trebled to 5.8%. The CR of the 25 largest firms increased from 23% to almost 57% over the same period.

This is a much lower level of concentration than observed in the New Zealand fisheries where in 2006 the 20 largest firms owned between 80% and 99% of the quota in different fisheries [24]. Connor [25] reports that in 1998 the ten largest firm held a combined 49% share in the New Zealand inshore fisheries, but the share was 90% in the mid-depth fisheries and 92% in the deepwater fisheries. For rock lobster, the CR-10 ratio was 26%.

Although the calculated HHI values indicate that market concentration in the Icelandic fisheries is still weak and that the market is quite competitive, the index has increased for both fleet segments. In the fishing year 2014/2015 HHI measured 432 for the large vessels but 183 for hook-and-line boats. These results are similar to the HHI value of 330 reported by Connor [25] for the New Zealand inshore fishery in 1998, but much lower than Connor's estimates for the mid-depth and deepwater fisheries, 1360 and 1601. In another study on the New Zealand fisheries, Stewart and Callagher [24] reveal HHI estimates of 865–2761, depending on the species involved. Haynie [27] shows that concentration for companies utilising lease rights in the Western Alaska Community Development Quota program had increased, and reports a HHI value of around 350. A study on the red snapper in the Gulf of Mexico found HHI scores of up to 192.

The distribution of quota holdings as measured by Lorenz curves and Gini coefficients has become more skewed through the years. According to Palsson and Helgason [18], the Gini-coefficient measured 0.769 in 1992 and 0.799 in 1994, while the estimates presented here yield a value of 0.870 in the fishing year 2001/2002 and 0.957 in 2014/2015. The hook-and-line vessels have experienced a similar development. The Gini-coefficient measured 0.513 in 2001/2002 but had increased to 0.909 in 2014/2015. Consolidation in Iceland is on par with developments in New Zealand. The Gini index for the mid-depth fisheries was 0.969 in 1998, but slightly lower, or 0.802 and 0.879 for the deepwater and in-shore fisheries. In the rock lobster fishery it measured 0.581 [25]. Abayomi and Yandle [14] report Gini-coefficients ranging between 0.440 and 0.810 in the period 1987–1990, but consolidation in the various New Zealand fisheries had by 2007–2009 increased to 0.64–0.95. Estimated Gini-coefficients for Canada's Scotia-Fundy inshore groundfish fishery are somewhat lower, or 0.831–0.898, depending on the type of fishing gear used [10], and even lower in the red snapper fishery in the Gulf of Mexico, or 0.747–0.812.

The consolidation in the Icelandic fishing sector has led to a decrease in both the number of harvesting companies and the number of vessels. At the beginning of the 2001/2002 fishing year, 582 firms were operating vessels with regular quotas and 496 firms operated boats with hook-and-line quotas. By 2014/2015, only 174 firms owned vessels with regular quotas (a 70% decline), while the number of hook-and-line operators had shrunk to 307 (a 38% decline). The fleet of vessels holding regular quotas has dwindled from 870 to 258 (70% decline), and hook-and-line boats from 810 to 318 (61% decline). The figure for the hook-and-line

boats in 2001/2002 includes 219 boats operating under effort restrictions, most of which later entered the quota system. If these boats are excluded the reduction in the small boat fleet amounts to 46%. It should be noted that these figures only refer to the number of vessels, both large and small, that held quota allocations at the beginning of each fishing year. The number of active vessels in the Icelandic fishing fleet is larger.

The performance of the Icelandic fisheries has improved considerably since the introduction of the quota system in Iceland's main demersal fisheries in 1984, and the more comprehensive management system in 1990. Thus, Arnason [22] shows that profits in the industry increased in the 1990s and Eggert and Tveterås [44] that labour productivity increased fast in Iceland during the 1990s, but the total factor productivity, adjusted for the stock size of the main species harvested, was lower in the period 1990–2003 than in 1973–1990. Better profits and higher labour productivity are probably due to economies of scale, which as noted by Stewart and Callagher [24], is one of the driving forces behind consolidation in fisheries. In their analysis of longline fishers in Hawaii, Pradhan and Leung [45], demonstrate that the probability of a vessel to stay in a fishery increases as profits in the fishery rise, but boats are more inclined to exit if the fleet is large or if stocks of the major target species are declining. The Icelandic fishing fleet was much too large when the quota system came into effect and this fact has no doubt encouraged some firms to leave the industry. Eggert and Tveterås [44] also reveal that Iceland's main demersal stocks declined during the period 1973–2003. This development may also have urged exit from the harvesting industry in the 1990s Smaller stocks will reduce profits as the cost of harvesting will increase, while at same time reducing each fishing years' harvest rights. Both effects will encourage exits.

Quota consolidation can also be explained in terms of risk aversion. Having access to quota of different species becomes essential if stocks of some harvested species decline while the status of others stays the same or even improves. As demonstrated by Kasperski and Holland [36], fishing is a risky business and the ability to move between fisheries is crucial for profit-maximising harvesters. In the Icelandic fisheries, this can be done by either trading for quotas or engaging the various existing catch-quota balancing mechanism [46].

The effects of the ITQ system on the regional distribution of fishing rights have been hotly contested in Iceland ever since the management regime came into effect [18,20,47–49]. Clear evidence is found of transfers between harbours and a growing consolidation between communities with regard to the quota shares of hook-and-line boats. The spatial distribution of quota shares of larger vessels appears to have changed less during the period under consideration. However, results from this study also indicate that spatial concentration has been much less than consolidation at firm level. This would indicate that firms have mostly grown in size by merging with local firms or buying out smaller local operators.

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Glossary

CR: Concentration ratio;
EC: European Commission;
DoF: Directorate of Fisheries;
GRT: Gross registered tonnage;
HHI: Herfindahl–Hirschman index;
ITQ: Individually transferable quotas;
MRI: Marine Research Institute;
TAC: Total allowable catch.