Assigning property rights to some but not others. An empirical investigation.

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Abstract

We analyze effects of some imperfections in the Icelandic Fisheries management system. Icelanders gradually adopted an Individual Transferable Quota (ITQ) system in the Icelandic fisheries. This property rights based system yielded benefits to the economy but was not applied to all fishermen. Some fishermen remained outside of the ITQ system and were subject to other management measures. In this paper we investigate whether and how those who stayed outside of the property rights system benefitted from the responsible behaviour of the ITQ fleet. Empirical estimates from duration model analysis are presented which measure the effects of various management measures aimed at effecting the behaviour of those 'outsiders' as well as the indirect effect of the ITQ system on the behaviour of those who stayed outside of it. The focus of the analysis is on the behaviour of economic agents under different institutional settings. The conclusions show that outsiders had incentives to stay outside of the ITQ system and free-rided from the behaviour of the ITQ fleet. Management measures aimed at restricting their effort proved to be useless. The conclusions can be generalized to other situations where property rights based management systems are used and economic agents harvest a common resource pool.

Introduction

The aim of this study is to analyze some effects of some imperfections in the Icelandic fisheries management system. An ITQ system was introduced in stages in the Icelandic fisheries, starting in 1979. First in the pelagic fisheries, but later in demersal fisheries. The system is based on sound economic principles and a well established theory. From an economic viewpoint its stated aim is to maximize the profitability of the resource extraction activity, with the probable side-effect of conserving the fish stocks.

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Although the design of the system is based on economic and scientific principles its implementation has somewhat deviated from the thoretical ideal. Its implementation was marked by political and socio-economic factors. As pointed out by Eggertsson (2005) such major institutional reforms as introducing property rights in fisheries is a subtle art. In the period 1984 to 1990 an ITQ system had been implemented in almost all fisheries in Iceland with the notable exception of small scale fishermen. This is not the only deviation from an ideal ITQ system. One should e.g. mention that a large part of the fishing industry is located in rural areas and the legislator has been reluctant to introduce measures which might have resulted in excessive imbalances among regions. This is one of the reasons that small boat operators where exempt from the ITQ system in the beginning and where left to operated under an effort-restriction regime. It soon became clear that effort restrictions proved of little effect so the legislator found it almost impossible to leave it at a *status quo*.

In what is to follow we will first give a brief outline of the management measures aimed at small scale fishermen from 1984 onwards. Secondly we present findings from a empirical estimation where we used duration analysis to measure the effect of various management measures. We argue that not only were the management measures unefficient but also we test the theory that small boats free-rided on the ITQ system, or more specifically, that all the conservation efforts, i.e. reduction of effort, was borne by the ITQ fleet but not the small boat fleet. The latter benefitted from the responsible behaviour of the former. In this study we focus solely on the cod fishery, it being the most important demersal fishery in Iceland.

Effects of Regulation and Spillovers

In what is to follow we study the effect of regulation and spillover effects on the exit of boats from one fisheries management to another. Using data on the Icelandic fisheries management system we estimate a Cox proportional hazard model of exit from a days-at-sea regime and incorporate both regulatory measures and the behaviour of firms in a contemporaneous ITQ system. The novelty is to incorporate both regulatory measures and effects of externalities as covariates with exit behaviour in an industry. Fishermen do not differ from other economic agents in the fact that they behave rationally. They maximize their utility given the numerous constraints they face. Those constraints are both due to natural circumstances such as weather conditions, non-observability of the prey and limited knowledge about the nature of the resource which they harvest, but other constraints are due to man-made measures such as the general regulatory framework in which they operate.

It is fairly easy to show that when there are two fleets which operate under different management systems but harvest a common resource they inflict spillover effects on one another.[1] Although those effects have been known to exist very few studies have attempted to measure this effect. In fact, the novelty of this paper lies in trying to estimate empirically the influence of regulation on entry and exit. In a survey on the theoretical and empirical aspects of entry, the effect of institutional frameworks is almost totally absent from the stylized facts which can be learned from the literature.[2]

Secondly, although the theoretical effects of regulation are well known, empirical

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[1] See Haraldsson (2006).
[2] Geroski (1995).

papers which estimate the magnitude of those effects are few.

To our knowledge, very few papers have tried to incorporate the institutional framework and changes in regulation into empirical analysis.[3]

The literature on entry and exit of firms is large.[4] This paper aims to contribute to the literature by measuring those two effects by using a Cox proportional hazard model on data on the Icelandic fisheries management system. Such models have been widely used both in economics but also engineering and medical studies.[5] In economics the focus has mainly been on exit and entry in various industries such as recent studies by Görg and Strobl (2003) which study the effects of multinational companies on the survival of companies in Ireland and Disney, Haskel and Hedens (2003) which study entry, exit and survival of firms in UK manufacturing. Studies on natural resource extracting industries are scarce and although numerous papers deal with incentives in fisheries management few papers try to estimate the impact of those incentives empirically.

Specifically we estimate Cox-proportional hazard rates for exit from the days at sea regime in the Icelandic fisheries. What we are especially interested in is whether and how regulation measures affect the hazard rate and to explore the possibility that behaviour of firms outside the system influence the exit rate. The data is firm (boat) level data from 1992 to 2004.

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[3] For an example see Bhattacharjee et al. (2004).

[4] See. e.g. Caves (1998), Hopenhayn (1992) and for a survey, Geroski (1995).

[5] For a medical study using time dependent covariates see, e.g. D'Agostino et al. (1990).

Our analysis is divided into four parts. The first part gives an overview of the management measures which have been taken since 1980 and as such sets the stage for the analysis. The second part describes and discusses the data. In the third part we estimate a Cox-proportional hazard rate of exit for the boats.

Fisheries Management and the Small Boat Fleet in Iceland

Gradually since 1979 an Individual Transferable Quota (ITQ) system was gradually introduced in the Icelandic fisheries. The fishing industry plays a key role in the country's economy and sign of overfishing incited the government to introduce the new system.[6] From the beginning of the ITQ system small boats were exempt from it. It soon became evident that the small boat fleet was freeriding on the ITQ system. Their share of the total catch increased and the burden of working in a responsable fisheries management system was borne by boats operating under the quota system. Those small boats were subject to days-at-sea restrictions and other technical constraints, described below.

The fleet consisted initially of vessels measuring less than 10 GRT, most of them around 10 GRT. They are rather homogeneous with regards to construction, made of fiberglass with powerful engines (max. speed ca. 30 knots) and with a holding capacity of up to 3 metric tons of fish. The crew is usually two persons although they can be operated by a single fisherman. The boats are designed to operate hand-lines but may also use long-line or gillnets.

They fish almost exclusively demersal species, mostly cod, but also haddock, saith and other species.

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[6] For a more thorough description of the Icelandic fisheries and its management see e.g. Arnason (1991).

The government tried to induce the small boat owners to exit the days-at-sea regime and join an IQ system for small boats. The difference between the IQ system for small boats and the ITQ system for others is the lack of transferability of quotas. Although the restrictions became more and more stringent over time there was an inherent resistance among those small boat owners to exit the days-at-sea regime and join the IQ system. It is important to note that once a boat has left the days-at-sea regime it is impossible to return to that system at a later date. We will argue that the reason for the resistance to exit lies mainly in the free riding possibility mentioned above, which we may also refer to as spill-overs from the quota systems and the well known inefficiencies of technical constraints as fisheries management tools.

Finally the Ministry of Fisheries abolished the days-at-sea regime in late 2004 by regulation.

Chronology of management measures

As mentioned above the small boat fleet has been operating under many types of fisheries management systems the landmarks being the following:

- 1980-1985: Free fishing. Prior to the introduction of the ITQ system, vessels under 10 GRT were not under any fisheries management whatsoever. When the ITQ system was introduced those boats were outside of the system. According to law the operations of those boats could be stopped, however, if the total catch of the fleet exceeded a pre-determined amount. This clause was never implemented.

- 1986-1990: Effort restriction regime. In an effort to try to limit the cod catch of the small vessel fleet, a system of limited fishing days was introduced in 1986. That same year the boats were banned from fishing for 49 days. A year later the number of banned days was increased to 64 days and in 1988 to 1990 the number of banned days was 69 days. In addition the legislator put a maximum allowable amount of cod catch on vessels using gillnets.

- 1991-1995: Effort restrictions and ITQs. In 1991 it was decided that boats measuring 6-10 GRT should be incorporated into the ITQ system. Boats who measured less than 6 GRT where offered to choose between ITQs and a specially designed hook and line limited effort system. Only a small number of vessels opted for the ITQ system. The remaining boats were obliged to use either hooks or long-line but were banned from using gillnets. In addition they only had a limited number of fishing days which were reduced in number from year to year.

- 1996-2001: Special small boats ITQs and more restrictions. Still, in order to constrain the catches of the small boats, those outside of the ITQ system were given the option to enter a specially designed small-boats ITQ system for cod which had the special feature that the quotas were not transferable to other than small boats. Those who decided not to take this option where banned from fishing for a total of 176 days.

- 2001-2004: An extended small-boats ITQ system. In 2001 a special hook and line ITQ system was introduced for the smallest boats which was similar to the one from 1996, except that now other demersal species than cod were also introduced. The only allowable gear within this system was hook and line. Numerous boats of those still on
- fishing-days restrictions opted for this extended system.

- 2004: A complete small boats ITQ system. In 2004 the minister of fisheries finally decided that all boats who still operated under effort restrictions should be incorporated into the small boat ITQ system. The only exception was for new boats with insufficient catch history. Those were required to enter the ITQ system in the next two years as
- the accumulate catch history.

It should be noted that although the law has consistently stated that small boats entering the ITQ system should not be alloted quotas based on catch history, they have nevertheless nearly always been based on previous catches.

The Industry and the Resource

According to the theory an ITQ system induces a change in the behavior of fishermen. Permanent property rights should, at least to some point, diminish the negative externality effects, which should reduce their effort, *ceteris paribus* with a subsequent effect on the resource stock. According to our thesis, it is this change in the ITQ-fleets behavior, which through the effect on the stock has an indirect effect on the behavior of the boats which are outside of the system.

The effect of introducing and ITQ system on the resource can be clarified with a simple classic dynamic fishery model.[7]

In what follows we will assume that there exist simple relationships between the covariates and the decision of boats to stay in the days-at-sea regime or exit. One would *a priori* assume that those are simple causal interactions, e.g. that diminishing the number of allowable fishing days would *ceteris paribus* limit the firms profits and therefore incite exit. An underlying assumption is that different fleets inflict externalities on each other with their respective behaviour.[8]

The Icelandic ITQ system and the cod stock

There is an inherent difficulty when judging whether the Icelandic ITQ system has been a success or not. The reason being that we do not know how the industry, let alone the resource, would have fared under some other management system.

The interplay between natural circumstances in the ocean, the multispecies interactions and the effect of the fishing activity is difficult to decipher. Although some scholars have criticized the system on various grounds, it is hard to find convincing evidence which points to the system being inefficient, or having totally failed its economic goals of increasing profitability and at the same time reducing effort. Most of the critique is aimed

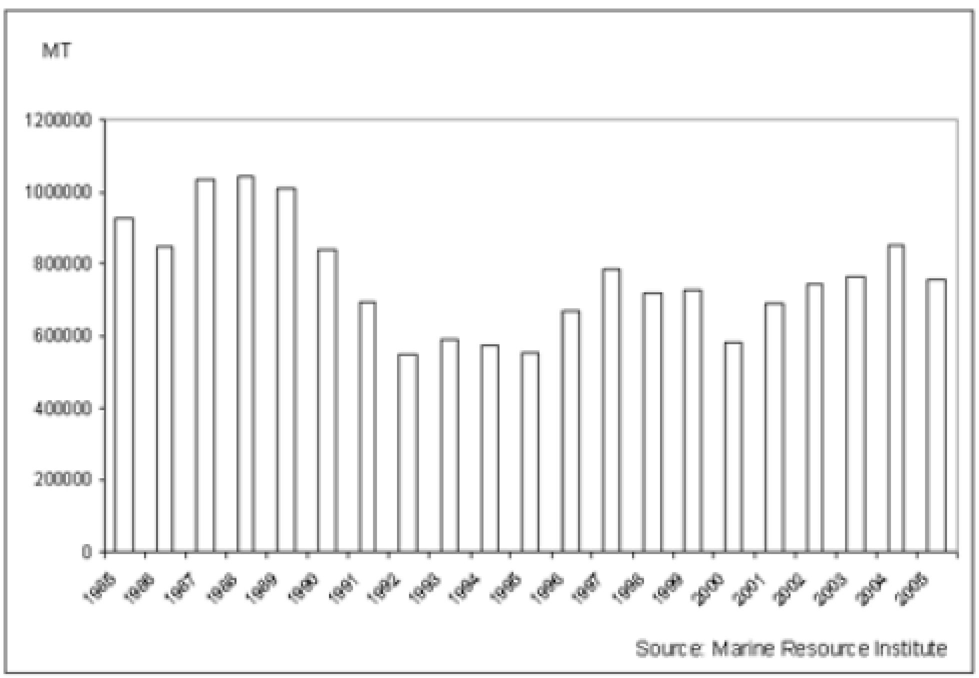
[7] Classic references are Clark (1976) and Clark (1985). A very clear exposition of the model and its details can be found in Arnason (1990).

[8] See Haraldsson (2006).

at the regional impacts of the system or the unfair grandfathering of the fishing rights when the system was being introduced.[9] It is a common claim that the ITQ system has failed to 'build up' the stocks. Having in mind the inherent complexity of the ecosystem it is difficult to draw any clear conclusion from data on overall catches or stock measurements.

What is of main interest to our analysis is the evolution of the cod stock over the period of observation as this is the stock that the decision makers face. The following figure shows the trend in the fishable stock (+3 yrs) from 1985 to the present.

Figure 1. Fishable cod stock 1984 to 2005.

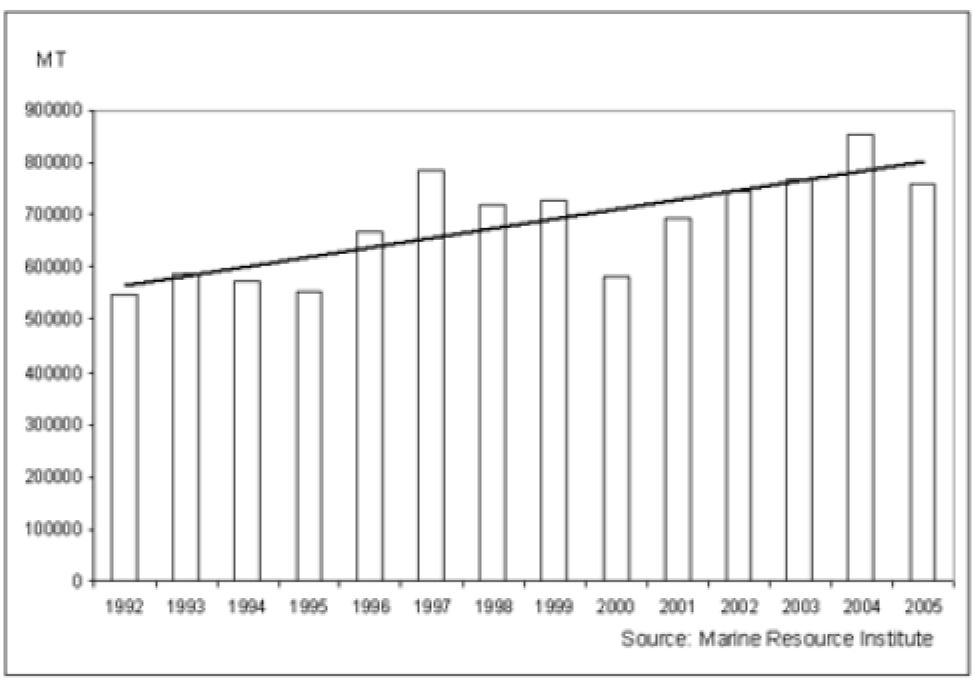


[9] For an analysis of the regional impact of the system see Runolfsson (1997). A discussion on the question of justice regarding the initial allocation of quotas has been less forma. Most of the critical points are made in Gylfason (1993), but regretfully its in Icelandic.

Looking at this figure, it is not easy to draw the conclusion that the cod stock has been growing steadily since the introduction of the ITQ system in the mid-1980's. But having in mind that the system was introduced gradually over the years it is more clarifying to focus on the years when the system starts to work with full impact.

In the next figure we have simply reduced the time scale to the period under scrutiny, i.e. from 1992 to 2005, otherwise the figures are identical. This figure shows almost a steady increase in the fishable stock size. And the increase is not negligible. The fishable stock size has grown from around 550 thousand tonnes in 1992 to around 800 thousand tonnes in 2004/5.

Figure 2. Fishable cod stock 1992 to 2005.



This data makes it clear that the resource which is being faced by the fishermen has been increasing almost constantly over the period of observation. Our simple claim is that this increase, induced by a more responsible fishing management system, has affected the behavior of those outside of the system.

The Data

We have data on the number of fishing boats under each management system and also aggregated catches for each fleet. Also we have more microeconomic data on the characteristics of each boat, i.e. size of the boat (GRT), home-port location, engine size and catches for each boat. The catch data are very detailed, e.g. on a monthly-basis.[10] Such a data set makes it possible to estimate a hazard rate function which is aimed at explaining the flow of boats from one system to the other (i.e. in and out of the effort-limitation system). When we look at the data we see that the number of outsiders has been decreasing over the period from 1992 to 2004.

[10] All the basic data on boats and their respective catches and characteristics was provided by the Directorate of Fisheries.

Table 1. Number of ‘outsider’s and their average catches

season	*no. of boats*	*average catch per boat*
'92-'93	987	22.256
'93-'94	1002	31.231
'94-'95	1022	33.402
'95-'96	592	27.575
'96-'97	422	49.249
'97-'98	363	36.192
'98-'99	304	25.481
'99-'00	299	30.304
'00-'01	301	32.245
'01-'02	288	43.119
'02-'03	296	37.243
'02-'03	293	32.668

An interesting thing to notice is that although the number of vessels outside of the ITQ system decreases drastically over the period the catch per boat does not. If we look at the total catch of cod over the same years

Table 2. Total catch of cod

season	*total cod catch*
'92-'93	205.964
'93-'94	129.581
'94-'95	121.828
'95-'96	138.458
'96-'97	153.786
'97-'98	189.725
'98-'99	208.537
'99-'00	183.876
'00-'01	182.100
'01-'02	160.603

it is evident that the stable catches are not due to bigger overall catches of cod. If we group the vessels according to their timing of exit, we get some interesting phenomena. Those that exited after 1997 had a peak in catches that year, although no such peak can be detected in the total catch of cod that year when looking at the whole fleet. This can also be detected by looking at the percentage of the catch of the outsider's fleet over the years.

Table 3. 'Outsider's' share of total catch

season	*percentage*
'92-'93	14%
'93-'94	30%
'94-'95	35%
'95-'96	14%
'96-'97	15%
'97-'98	7%
'98-'99	4%
'99-'00	5%
'00-'01	6%
'01-'02	8%

Those are very crude results from crude data, nevertheless they clearly indicate that a more detailed analysis could disentangle common effects from individual effects.

1. Economic theory would suggest that if some inputs are constrained by regulation (days-at-sea) then the boats increase the use of other substitutable inputs.

2. If the stocks are getting bigger due to the constrained effort by the ITQ fleet, the outsiders have access to this bigger stock so their catch per unit of effort should, *ceteris paribus* increase.

3. Possible changes in the behaviour or nature of the stock.

Quite possibly the explanation is a combination of the first two factors mentioned above. The third possibility is out of the scope of this inquiry.

Who exits and when?

It is not easy to draw conclusions about the exit decision of the fishermen by simply looking at the data. However some descriptive statistics are in order.

The following table shows the number of boats for which the stated year was the last one inside the effort management system.

Table 4. Number of boats exiting

season	*no. of 'exits'*
92'93'	32
93'94'	49
94'95'	409
95'96'	193
96'97'	75
97'98'	57
98'99'	34
99'-00'	23
00'-01'	24
01'-02'	28
02'-03'	23
03'-04'	293

It is clear that there was a boom in exits in 1995 until 1998 but since then the number of exits was much lower. The great number of exits in 2004 signifies the closing of the old system so those are simply all the remaining boats. According to information provided by the Fisheries Directorate almost all those boats entered into a quota based system.

Entries

One of the main criticizm concerning the 'outsider's' of the ITQ system was that although the legislator tried to induce the vessels to join the ITQ system, there were still possibilities for certain vessels to enter the small vessel system. By looking at our data set we can see how many boats entered in the period under scrutiny, as is shown in the following table.

Table 5. Number of entries

season	*no. of 'entries'*
93'-94	72
94'-95'	72
95'-96'	10
96'-97'	12
97'-98'	6
98'-99	6
99'-00'	13
00'-01'	10
01'-02'	9
02'-03'	28
'03-04'	14

It is important to notice how we define 'entries' and 'exits'. 'Entries' are those that start fishing in a certain season within the period under observation. 'Exits' are those which stop fishing in a certain season and do not resume their activity within the data period. It is not uncommon in the literature to emphazise the role that size of firms plays in entry and exit.[11] The data at hand clearly shows that due to formal restrictions on size it is hard to see any clear trend in boat sizes over the period. Most measures, such as GRT, show that the boats characteristics are quite homogeneous. The hp (horsepower) of the engines has however increased considerably over the period. However, looking at the average catches for each group of boats, i.e. 'entrants', 'exits' and all 'active' vessels, clearly shows that they differ with regards to catches.

[11] Geroski (1995) for further discussion on this point.

Table 6. Average catches

season	*'exits'*	*'enters'*	*active*
92'-93'	22.256	6.004	21.725
93'-94'	31.231	5.244	14.574
94'-95'	33.402	42.298	32.242
95'-96'	27.575	22.723	53.040
96'-97'	49.249	36.575	69.861
97'-98'	36.192	34.302	51.390
98'-99'	25.481	11.684	35.317
99'-00'	30.304	23.518	45.697
00'-01'	32.245	28.597	44.960
01'-02'	43.119	20.107	74.205
02'-03'	37.243	26.827	34.911
03'-'04'	37.243	32.668	37.853

In this table we are comparing each group for each year, which means that e.g. in the season '92-'93 those who exited that year catched on average 22 tons, those who entered that year catched on average 6 tons and the average catch for all active boats (including those who exited and entered) was on average a little less than 22 tons that season.

It is clear from this that those who exit used to catch more than those who did not. In the last seasons those average catch rates converged.

An Extended Cox Hazard Rate Model of Exit

In order to gain further insights into the exit behaviour of boats from the days at sea regime into the quota system we estimated a Cox proportional hazard model. The main difference between hazard regression models and discrete outcome models (such a probit, logit, etc.) is that the former take the timing of alternative outcomes explicitly into account and makes it possible to segregate the age aspect of the propensity to exit or entry from the effect of other covariates. It is therefore possible to disentangle the general effects of rules and regulation (incentive structure) from those which can be considered to be firm- or industry specific.

If we denote the hazard rate of boat *i* by λ_i i.e. the probability that this boat exits in the interval from *t* to *t+1*, (given that he did not exit before) then

$$\lambda_{it} = \lambda_0(t) \exp^{\beta X_t}$$

and λ_0 is the baseline hazard function whose parametric form we do not specify, when all covariates are set to zero. *X* is a vector of explanatory variables which influence the hazard rate.

The covariates we use in the following estimation are; **GRT**, i.e. gross registered tons of the vessel, maximum days-at-sea allowed (\emph{maxdays}), catch of boats (**catch**), the number of trawlers in the ITQ system, \emph{notrawl} and finally the catch per GRT of the trawler fleet (**catchpgrt**), the size of the fishable stock (**fishstock**) and finally the price of quota in the ITQ system (**quotaprice**).

Using some indicator of size are standard in this kind of analysis but due to the homogeneity of the small boat fleet we believe it is more appropriate to look at the catch of the boat as it indicates not only its capacity but also the intensity of its fishing activity. The size of the fishing stock is an appropriate measure of the quantity of fish that each vessel (or rather manager) faces and the quota price is theoretically an indicator of the success of the fishing management system.[12]

In order to facilitate the interpretation of the estimation results, the variables have been scaled by factors of 10, 100 or 1000 to obtain similarities in magnitutes. This does not effect the statistical outcomes otherwise.[13]

The results of estimating the hazard model with a sample of 239 boats, with a total of 6116 observations are shown in the following table. Cohort dummies have been included.[14]

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[12] On this last issue see Arnason (1990) where it is argued that in order to maximize the social welfare, fisheries management should choose the TAC level which maximizes the price of quota.

[13] The calculations were performed usingthe StatsDirect statistical software, version 2.5.5.}

[14] Some might argue that observing the whole fleet renders statistical methods based on sample theory useless. Nevertheless we argue that although observing the whole population the underlying forces and phenomena apply to a super-population not directly observable. In that sense our data is a sample taken from such a population.}

Table 6. Estimation results A

Covariate	*Coefficient*	*95% CI*	*p-value*	*Hazard ratio*	*95% CI*
catch	-0,000447	[-0,000743;-0,000152]	0,003	0,999553	[0,999258;0,9999848]
GRT	0,121543	[0,080081;0,163006]	<0,0001	1,129238	[1,083375;1,177043]
maxdays	0,016671	[-0,012421;0,045763]	0,2614	1,016811	[0,987656;1,046827]
sumvstac	-0,001275	[-0,044541;0,041991]	0,9539	0,998726	[0,956437;1,042885]
notrawl	-0,136311	[-0,372976;0,100353]	0,259	0,872571	[0,688682;1,105562]
catch/grt	0,012955	[-0,010966;0,036875]	0,2885	1,013039	[0,989094;1,037564]
catch/day	0,000082	[-0,000047;0,000211]	0,215	1,000082	[0,999953;1,000211]
fishstock	0,9267222	[0,314978;1,538465]	0,003	2,526213	[1,370229;4,4,657435]
quotaprice	-0,184139	[-0,279168;-0,08911]	0,0001	0,83182	[0,756413;0,914745]

Log likelihood with no covariates = -10437,43793

Log likelihood with all model covariates = -9679,202865

Deviance (likelihood ratio) chi-square = 1516,47013

$P < 0{,}0001$

We will give a thorough evalutation of the estimation restults below, but the table above shows the results when all the covariates have been incorporated into the model. The signs are as one would expect but we see that some of the parameters are not statistically different from zero. It should be kept in mind that the coefficients in a Cox regression relate to hazard so that a positive coefficient indicates a negative effect on not exiting and similarily a postive effect indicates a postive effect on 'survival' of the covariate under scrutiny.

If we drop number of trawlers and the share of the 'outsider' fleet of the total catch we get the following results.

Table 7. Estimation results B.

Covariate	*Coefficient*	*95% CI*	*p-value*	*Hazard ratio*	*95% CI*
catch	-0,000449	[-0,000744;-0,000153]	0,0029	0,999552	[0,999257;0,9999847]
GRT	0,121683	[0,080269;0,163096]	<0,0001	1,129396	[1,083579;1,177149]
maxdays	0,00367	[-0,013302;0,020642]	0,6717	1,003677	[0,986786;1,020856]
catch/grt	0,012919	[-0,011001;0,036839]	0,2898	1,013003	[0,989059;1,037526]
catch/day	-0,000082	[-0,000047;0,000211]	0,2141	1,000082	[0,999953;1,000211]
fishstock	1,002372	[0,56743;1,437341]	<0,0001	2,724737	[1,763681;4,209486]
quotaprice	-0,17566	[-0,238803;-0,112517]	<0,0001	0,838903	[0,78757;0,893582]

Log likelihood with no covariates = -10437,43793

Log likelihood with all model covariates = -9679,721081

Deviance (likelihood ratio) chi-square = 1515,433696

$P < 0{,}0001$

Those results are very similar to the specification using all the covariates. There are neither changes in signs, nor considerable differences in magnitudes between those two specifications. The covariates which may be interpreted as proxies for efficiencies or intensities of effort (catch/day and catch/GRT) are still not significantly different from zero. Therefore it seems that the main factors which influence the probability of a boat exiting the days-at-sea regime is the catch volume of each boat, the size of the fish stock they exploit and the quota price. The effort restriction, maximum allowable fishing days, is also not statistically different from zero, but we nevertheless include it in the models specification to see if that changes with omitting other covariates. The following table shows the estimation results when catch/day and catch/GRT have further been dropped out of the specification.

Table 8. Estimation results C.

Covariate	*Coefficient*	*95% CI*	*p-value*	*Hazard ratio*	*95% CI*
catch	-0,000335	[-0,000572;-0,000097]	0,0058	0,999666	[0,999428;0,999903]
GRT	0,122123	[0,080756;0,163489]	<0,0001	1,129396	[1,083579;1,177149]
maxdays	-0,004853	[-0,01172;0,002014]	0,166	0,995159	[0,988348;1,002016]
fishstock	0,783392	[0,624164;0,942621]	<0,0001	2,188885	[1,866684;2,5667]
quotaprice	-0,149359	[-0,1897216;-0,109002]	<0,0001	0,86126	[0,827194;0,896729]

Log likelihood with no covariates = -10437,43793

Log likelihood with all model covariates = -9680,850239

Deviance (likelihood ratio) chi-square = 1513,175382

$P < 0{,}0001$

The result of dropping catch/day and catch/GRT seems to have the only notable effect of lowering the hazard rate for the fish stock, but this decrease does not seem to be of a great magnitude and does not alter the main results in any way.

Finally, we represent the estimation outcome when all covariates but GRT, the fishable stock size (fish stock) and the quotaprice have been omitted from the model. The following table reports the results.

Table 8. Estimation results D.

Covariate	*Coefficient*	*95% CI*	*p-value*	*Hazard ratio*	*95% CI*
GRT	0,092052	[0,056118;0,127986]	<0,0001	1,096422	[1,057723;1,136537]
fishstock	0,795045	[0,636001;0,954089]	<0,0001	2,21454	[1,888913;2,596303]
quotaprice	-0,150353	[-0,190704;-0,110001]	<0,0001	0,860405	[0,826377;0,895833]

Log likelihood with no covariates = -10437,43793

Log likelihood with all model covariates = -9685,585364

Deviance (likelihood ratio) chi-square = 1503,705131

$P < 0{,}0001$

Again, the main findings are intact and it seems that those are the factors which have the greatest impact on the probability of exit from the days-at-sea regime.

As survival analysis has its origins in medical science it is often easier to think in terms of patients and treatments rather than in economic terms. Seen in this light we may think of the firms/boats as unities which probability of exiting is influenced by their respective characteristics and the 'treatment' they receive. In our case the main characteristics are their size (GRT), how much they catch (catch) and how efficient they are (catch/grt) and catch/day. The 'treatment' they receive is of two types Firstly, there is the direct management measure, i.e. the maximum fishing days allowed (maxdays) and secondly there are derived effects of other management measures, such as the size of the fishable cod stock (fishstock) and the quotaprice.

Those estimates are interesting in many ways. The statistical properties of the estimation seem to be satisfactory. Different specifications, where one or several covariates were dropped from the estimation do not change the main outcomes, signs of coefficients or signifcantly their magnitudes.

Perhaps the most striking outcome is that the chief regulatory measure, i.e. the maximum allowable days-at-sea seem to have an insignificant effect on the probability of exit. This result is however in accordance with the common belief that simple input restrictions are not an efficient way of controlling effort.[15] Fishing effort is a bundle of various input factors and there are numerous ways of subsituting one factor for another. This also rymes with the idea that this small-boat fleet is not the same now as it was a decade or two ago, as the fishing gear and motors have become more powerful than before. Unfortunately our data set does not allow us to analyse this further. Nevertheless, our

[15] See e.g. FAO (1983).

analysis stongly shows that limiting the allowable fishing days has been unsuccessful in inciting boats to exit the days-of-sea regime. The positive hazard ratio is even positive which implies that limiting the allowable fishing days has even had the perverse effect of lowering the incentive of exit.

The level of activity, measured by the catch level does not seem to be significant factor in affecting exit behavior from the system. This holds irrespectable of whether we measure efficiency by catch/GRT or catch/day. These results might also indicate a high level of heterogeneity between different boats, as reflected in relatively high standard errors.

Additionally, then it must be acknowledged that GRT is perhaps not a reliable measure of fishing power due to more powerful motors and fishing gear.

Turning to the two remaining covariates, we see that an increase in the fish stock which the boats observe induces them to exit, and vice versa, while the opposite holds for the price of quota. Here it must be kept in mind that the fish stock is the one that all fishing vessels observe, be they in the ITQ, IQ or days-at-sea regime. It is therefore difficult to estimate the overall effect of an increasing fishing stock as it is faced by the outsiders and the insiders. If we adopt the previously mentioned idea that the quota price is a gauge of the present and future success of the fishing management system as a whole we seem to be able to draw the conclusion that the apparement success of the system, as it manifests itself in the increasing quota prices, has an inverse effect of the decision to exit the days-at-sea regime.

Discussion

We have discussed the main features of the fisheries management system in Iceland for the period 1992 to 2004. An sometimes overlooked fact is that although the mainstay of the management system has been an ITQ system then a contemporanous system of effort restrictions (mostly using restrictions on the maximum allowable days at sea) has been in effect for the small vessels. During the last decade, the authorities have been inciting those small boat owners to enter a quota system, mostly by reducing the number of days allowed for fishing.

We argue that those measures have had little success partly owing to the fact that the small scale fishermen have reaped the benefits of the ITQ system, where vessels have reduced effort and contributed to the well-being of the stocks and industry.

Using a Cox proportional hazard model we estimate how various covariates affect the exit from the days-at-sea system our main findings are that reducing the number of allowable fishing days has contributed little to exits while the reduction of effective effort in the ITQ system has greatly hindered the flux of the small boats from the days-at-sea regime. Additionally, we have argued that the success of the ITQ system has partially delayed those who have been operating outside it to enter it.

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