Fish and Ships in the Baltic Sea - Prices, Demand and Management

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Fish and Ships in the Baltic Sea

Prices, Demand and Management

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Licentiate dissertation

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We're just two lost souls
Swimming in a fish bowl,
Year after year,
Running over the same old ground.
What have we found?
The same old fears.

(Pink Floyd)

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Contents

1. Introduction

1.1 Background

Fishing is one of the oldest economic activities of mankind and to this day it is still carried out in a way that has not changed much. What, then, are the concerns of a modern-day fisher? A Swedish coastal fisher working the Baltic Sea put it like this:

"The possibilities for the coastal fishery depend on fishing regulations and on the availability of fish, winds and streams, fish prices, how much time and money have to be spent on fishing, nets, and maintenance of the boat"[1] (Säwe and Hultman 2012, p.34).

Clearly, the fisher is concerned about the costs of fishing (cost of nets and time spent on fishing and maintaining the boat). But fish prices and fishing regulations are also important, since the market price will have to cover the costs, and regulations will affect costs as well as prices. The development of prices and effects of management decisions will be of interest to fishers and policy makers alike.

The topic of this essay is the first-hand market for fish where fresh fish is bought from fishers at port.[2] Fish that is landed in the ports is classified, registered and transported to processing facilities or fish auctions. In the processing facilities fish is filleted and frozen before being transported to domestic and international wholesalers and retailers who sell on to final consumers. More specifically, this essay is about the Swedish fisheries in the Baltic Sea with focus on the first-hand market for cod. This market has been undergoing profound changes during the last decade. The cod stocks have partly recovered from historically low levels, management and regulations have changed many times over the years, imports have increased, vessels have been scrapped and average cod price have decreased. In the light of these changes, it is of interest to study market demand, prices and effects of changes in management.

There are numerous reasons why the first-hand market for fish is of special interest from an economic perspective. First, fish is a primary product and the biological conditions of a fish stock are important for the resulting product. The availability of fish will affect the quantity of fish that is landed, but the quality of the landed catch will also be dependent on biology. For example, the age-structure of a fish stock is directly related to the size of the fish sold in the ports. Price can be explained by product attributes, and the effects on price of adding or removing an attribute can then be analyzed. Second, fish is a perishable product which implies that it is difficult for fishers to influence the price in the very short run; rather than leaving the fish to rot, it is sold at a price that only just covers the costs of the fishing trip. In addition, fishers have limited possibilities of affecting the size or quality attributes of fish in the short run, since it is difficult to aim for certain sizes or qualities while fishing. Assuming that fishers cannot affect prices in the very short run, for example on a daily basis, makes it possible to study demand, where buyers are the ones who can influence the price. By studying demand it is possible to see how prices change in the short run in response to quantity changes. However, it might be possible for fishers to affect prices in the long term; fishing

[1] Author's translation.
[2] The essay is part of the project Multidimensional co-management of coastal fisheries financed by Formas.

trips can be planned over a season, investments can be made and inputs can be replaced. Thus, it is probable that fishers have some kind of market power. Third, fishery resources are common resources which make government intervention in the market inevitable in most fish markets. Government intervention affects everything: the sizes of fish that can be landed, which fishing techniques can be used, where and when to fish and what quantities can be caught. In order to understand the effects of government intervention, studies on the effect on prices can give guidance to future management decisions. Fourth, the first-hand market for fish can be characterized by imperfect competition, since fish is often landed in remote areas, the number of buyers in each port is limited, and many fishers are dependent on their port of registry for family reasons.

However, the Swedish Baltic fishery is not operating in isolation; the management of this fishery will have effects on fisheries surrounding it, and the management of fisheries elsewhere will have effects on the Swedish Baltic fishery. More importantly, perhaps, for the fishers in the Swedish Baltic area is that the market for their products is not limited to the region. Fresh cod is transported from ports in the Baltic to processors in other parts of Sweden for processing with cod imported from other countries. Frozen and processed cod are highly traded products on the international market and first-hand markets for cod have been shown to be internationally integrated (Nielsen 2005). Prices of cod on the local market will thus be affected by world market prices. Still, although prices move in a similar manner, there is scope for variations on a local market, such as the Swedish Baltic cod market. Transportation costs, remoteness of ports, close-knit relationships between fishers and buyers and fishers' dependency on port of registry are factors that still matter for the local price formation process. Although the Swedish Baltic fish market is part of a larger European market, part of the price formation process is still local.

The second chapter investigates the prices of different attributes of cod, the third chapter deals with the price effect of a management change in the Swedish cod fishery, and the fourth chapter discusses what might happen when management is not applied to a small-scale fishery. The chapters are summarized below.

1.2 The big, the bad and the average

How much are buyers of cod willing to pay for increased product quality? How are prices affected when the quality of cod increases? The second chapter of this essay discusses the prices of attributes of cod and the effects on prices when the quantities of attributes change. The attributes studied are four different sizes and three different quality ratings. The quantities of attributes could change for biological reasons or because of management changes. For example, climate change could be favorable for a certain fish stock and increase the number of large individuals in that stock disproportionally. But the attributes of fish landed could also change with a new management regime, and perhaps a mesh size regulation that makes it impossible to land small fish. The study object is Baltic cod landed in Swedish ports in the period 1997-2011.

The results are important when modeling the effects of new management proposals on revenues, since changing quantities could result in new prices. As the composition of landings changes, the prices of different attributes will change and hence revenues could be affected. This chapter shows that the prices of different attributes differ, that prices depend on landed quantities, and that quantity effects are larger for prices of small cod than for large cod. It is also shown that different sizes of cod are substitutes, i.e. when cod of a particular size gets more expensive, buyers turn to cod of another size. Finally, over the time period studied, there is an increased demand for larger sizes of fish and fish with a higher quality rating.

1.3 Time for fishing

How are market conditions affected by a change in fishery regulations? Who benefits and who loses? The third chapter, co-authored with Johan Blomquist and Staffan Waldo, discusses the price effects of a reform in the Swedish Baltic cod fishery. In April 2011, as part of a reform process aimed at preventing fishers from throwing fish overboard, vessels using active gear were given annual quotas rather than the previously applied quarterly quotas. We investigate whether the bargaining power of fishers using trawlers have improved after the reform. Since fishers have more freedom to fish for cod over the year and processors are keen to have regular landings of fish (in order not to have unused capital), we suggest that prices are likely to increase following the reform.

The results indicate that prices have increased due to the increased bargaining power of fishers after the reform. We leave the effects of fish size, fish quality, landing port and landing date out of the analysis; if any of these factors changed due to the regulatory change, it did not affect our results. We also investigate whether the price change that we have found is driven by changes in reservation prices, i.e. the lowest prices a fisher would accept and the highest price a buyer would accept, and find that this is not the case. Thus, we conclude that introducing yearly quotas is likely to have changed bargaining power between fishers and buyers in the Swedish Baltic cod fishery.

1.4 Swedish coastal herring fisheries in the wake of an ITQ system

What happens when part of a fishery is left outside a system of Individual Transferable Quotas (ITQs)? The final chapter is co-authored with Staffan Waldo, Kim Berndt, Martin Lindegren, Anders Persson and Anders Nilsson and provides insights into the management design for small-scale fisheries. The Swedish small-scale herring fishery in the western Baltic Sea, which was exempted from an ITQ-system, is used as a case study.

The migratory pattern of the herring implies high densities in the southern parts of the fishing areas during spring and in the northern parts during autumn. This forms the basis for two fisheries in the area competing for a shared quota, as well as for the current management proposal to divide the quota into a spring and an autumn part. This and other management proposals are discussed in the paper. The main conclusion from the case study is that, when exempting a fishery from an ITQ-system, it is important to build other institutions dealing with the fundamental problem of access to the quota.

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2. The big, the bad and the average: hedonic prices and inverse demand for Baltic cod

2.1 Introduction

Much focus in fishery economics has been on the total biomass of the fish stock that is harvested without any consideration of the size or the quality of the fish. In order to maximize the economic value of a fishery, it is not just the weight in tons that matters, since attributes such as size and freshness can change the value of the catch substantially. In this chapter the prices of different sizes and qualities[1] are closely related to the management of fishery resources. Fisheries, such as the Baltic Cod fishery, are often regulated by quota restrictions set in tons of fish, with the size of the fish regulated by restrictions on mesh sizes and minimum legal landing sizes. As discussed below, a fish stock that is managed economically efficiently often has a larger amount of large sized fish as well as a larger amount of undamaged and fresh fish.

The pricing of size attributes is especially interesting since price has been the focus of a large number of studies relating fishery management to the size (or age) structure of the biomass (Döring and Egelkraut 2008, Froese; Stern-Pirlot; Winker et al. 2008, Quaas; Requate; Ruckes et al. 2010, Diekert 2011, Ravn-Jonsen 2011, Cardinale and Hjelm 2012). Numerous benefits of delaying harvesting until fish have reached a certain size have been pointed out. Firstly, the most obvious point is that larger sized fish increase the value of the total catch. Secondly, larger fish can also decrease uncertainties about the future stock since the spawning success will be less likely to be dependent on a single age group (Döring and Egelkraut 2008). Finally, societal values, like a good ecosystem status of the sea and higher values of recreational fisheries can be achieved in a fishery with larger fish (Cardinale and Hjelm 2012).

Quality attributes that are not related to size may be related to the status of the biomass stock, but will also depend on how the fish are handled after they have been caught. The incentive for fishermen to produce high quality fish is expected to increase in an economically efficient fishery, and fishermen will therefore deliver a larger amount of fresh and undamaged fish (Squires; Kirkley and Tisdell 1995, Larkin and Sylvia 1999, Grafton; Squires and Fox 2000, Carroll; Anderson and Martinez-Garmendía 2001). The price paid by fish processors to fishers is likely to depend on these quality aspects. Fish that have been handled more carefully and not stored for too long are expected to receive a higher price on the market. Hence, the pricing of quality attributes, other than size, is interesting from a fishery management perspective.

Using a unique and detailed dataset on the Swedish Baltic Cod fishery, this chapter takes a closer look at prices related to the size and quality ratings of cod. In addition, the study contributes to the literature on hedonic prices and inverse demand by using two methods (the random coefficient model and the Brown and Rosen method) suggested in the literature (Kristofersson and Rickertsen

[1] Although it is possible to refer to size as a quality, this paper regards size as separated from quality, and considered to be quality aspects related to freshness and appearance of the product as set down in the EU regulation *No 2406/96 of 26 November 1996.*

2004). Lately, the size and quality composition of Swedish Baltic cod have become an important issue as the problems of a diminishing fish stock, especially for Eastern Baltic Cod, have become less severe (BSRAC 2011, Cardinale och Hjelm 2012, Eero et. al 2012). Despite the recovery in the stock biomass, the size of the cod caught is still small (Cardinale and Hjelm 2012). Fishermen as well as society could benefit from larger cod and cod of better quality. The price premiums of different attributes, five size classes and two quality ratings, are investigated using the hedonic method. In addition, the effects of increasing the amounts of cod with different attributes are analyzed in an inverse demand system. Increasing the quantities of attributes is expected to result in decreasing attribute prices. By not considering these price increases, the benefits of sustainable management might be overestimated. Hence, the aim of this study is to offer guidance on the economic value of different size and quality compositions of cod landings.

The paper proceeds with a short description of the Swedish Baltic cod Fishery and the regulations surrounding it. This is followed by a description of the estimation of the hedonic model and the inverse demand model in the literature and in this paper. Next, the database of the Swedish cod fishery and some statistics based on the database are presented, as are the results from the hedonic inverse demand model. A discussion on how the results are related to fishery management issues brings the paper to a close.

2.2 The Swedish Baltic Cod Fishery

The Baltic Cod Fishery is one of the most important fisheries in Sweden; in 2011 around 17 percent of the value of all landings of fish and seafood in Sweden consisted of cod, mostly landed along the south coast of Sweden (Swedish Agency of Marine and Water Management 2012). The fishing areas include the Western Baltic (the Belt Sea, the Sound and the Arcona basin) and the Eastern Baltic (including the Bornholm basin, the Gdansk basin, the Gotland basin, the Bothnian Sea, the Bothnian Bay and the Gulf of Finland). In 2011 nine countries were fishing for cod in these two stocks in the Baltic. Poland, Denmark and Sweden were the major fishing nations in the Eastern Baltic while Denmark, Germany and Sweden fished in the Western Baltic Cod Stock. In total, 50 368 tons of cod was landed from the Eastern Baltic in 2011, of which 20 percent was landed by Swedish vessels; 16 332 tons of cod from the Western Baltic stock was landed, of which Swedish vessels landed 16 percent (ICES 2012).

The Swedish Cod fishery is regulated by EU legislation and national legislation that in some cases goes further than the EU regulations. The regulations consist of the setting of quotas, limiting the number of days out of port, fishing bans and closed areas. A multiannual plan (European Commission 2007) for the cod stocks in the Baltic Sea was established in 2007, the motivation being a decline in the stock to levels where it was suffering from reduced reproductive capacity and unsustainable harvesting. The purpose was to gradually reduce and maintain fishing mortality rates at levels no lower than 0.6 for cod aged 3 to 6 years for the Western Baltic stock and 0.3 for cod aged 4 to 7 for the Eastern Baltic stock. This regulation also stipulated prohibited periods and closed areas for the two Baltic cod stocks. Fishing with most types of fishing gear is prohibited from the 1st of April until the 30th of April in the Western Baltic Sea (the April closure) and from the 1st of July until the 31st of August in the Eastern Baltic Sea (the summer closure). Most types of fishing activities in the Gdansk deep, the Bornholm deep and the Gotland deep (European Commission 2007) are prohibited from the 1st of May to 31st October. The number of days at sea is regulated from year to year in different

EU regulations. For example, in 2011, vessels were limited to 163 days absence from port in the Western Baltic Sea, and 160 days absence from port in the Eastern Baltic Sea (European Commission 2010). In addition, regulations require fishers to have licenses and vessel permits, and stipulate the allocation rules for fishing quotas. Special rules also apply to cod fishing, which requires a special permit in the Baltic Sea, and the number of ports with the right to receive more than 750 kilos of cod has been limited to 29 since 2005 (Swedish Board of Fisheries 2004, European Commission 2007).

Regulations related to the size of the cod are mainly requirements on mesh sizes and minimum legal landing sizes found in Council regulation no 2187/2005, which also lays down the technical measures for the conservation of fishery resources in the Baltic Sea. The regulations on mesh sizes for vessels using active gear are part of the detailed requirements for Bacoma and T90 trawls; the mesh size is set at 105 mm on the Bacoma trawl, except for the exit window which should have a minimum mesh opening of 110 cm. For the T90 trawl the mesh size should be at least 110 mm. For vessels using passive gear, mesh sizes should be larger than 157 cm when vessels only target cod, and between 110 and 157 cm when more than 90 percent of the target species consists of cod (European Commission 2005). Regarding minimum landing sizes, the EU regulation on technical measures, issued in 2005, establishes that the minimum length of cod from the Baltic Sea is to be 38 cm.

The attributes of cod fished in the Baltic are the result of biological conditions as well as management decisions. The regulations discussed above influence the size and quality composition of landings that are discussed in the following sections. A suitable model for estimating attribute prices is discussed in the next section.

2.3 The hedonic model and inverse demand

The most common model for the estimation of attribute prices is the hedonic model. The simplest form of the hedonic model is an equation where the price of a product is described as a function of the attributes of that product:

$$p_n = \boldsymbol{z}'_n \boldsymbol{\beta} + \varepsilon_n \tag{1}$$

where p_n are observations *n* of prices of a product, $\boldsymbol{z}'_n$ is a vector of observations of different attributes, $\boldsymbol{\beta}$ is a vector of average attribute prices which is to be estimated and ε_n is a random factor influencing the price of the product.

Hedonic price analysis is often used to explore revealed preferences of quality attributes where no market prices exist. The attribute prices of colour, size and uniformity of spears of asparagus were estimated by Waugh (1928) in the very first paper on hedonic prices. Since then, the method has been widely used to estimate not only prices of the attributes of different products, but also the revealed preferences of environmental amenities. In relation to fish markets, McConnell and Strand (2000) use a hedonic function including landed quantities of different fish species to investigate the qualities of Hawaiian Tuna sold at fish auctions. Hedonic prices have also been estimated by Roheim; Gardiner and Asche (2007) with a hedonic pricing model to determine the relative value of the attributes of frozen processed seafood in the UK. A recent study by Asche and Guillen (2012) investigates the prices of hake caught by longline, trawl and gillnets in the Spanish whole-sale market. The results show that fish caught by longline are more expensive than fish caught by trawl or gillnets. However, hake caught by gillnets have smaller price premiums than hake caught by trawlers, which suggests that trawling does not reduce quality as much as gillnetting. The value of line-caught haddock and cod in British supermarkets is also investigated by Sogn-Grundvåg; Larsen and Young (2013) . The results suggest that there is a price premium for line-caught cod and haddock and thus that consumers pay more for line-caught fish compared to fish caught by other methods. This study also finds a price premium for fish labeled by the Marine Stewardship Council (MSC).[2]

All of the above studies focus on the hedonic price function as such, without considering how changing quantities of attributes affect hedonic prices. Rosen (1974) pointed out that this type of hedonic price function can only reveal something about attribute prices at prevailing quantities, since prices normally are determined by the demand as well as supply of attributes. Hence, in order to identify the demand and supply of attributes, a system of demand and supply equations should be estimated (Rosen 1974). However, it is possible that in markets like housing markets (Palmquist 1984) and markets for natural resources (Wang 2003), or fresh produce like fish (Barten and Bettendorf 1989, Kristofersson and Rickertsen 2004), the supply of attributes can be assumed to be exogenous. In this case the estimation of an inverse attribute demand equation for an attribute is possible:

$$\beta_t = \delta' \boldsymbol{q} + u_t \tag{2}$$

where β_t are observations of prices of the attribute, q are quantities supplied of different attributes and u_t are unobserved factors influencing the price of the attribute.

In order to estimate an inverse demand equation it is necessary for attribute prices to vary. One way to find variation is to use a non-linear hedonic model where hedonic prices differ among buyers who prefer different amounts of these attributes. A functional form of the hedonic model must be assumed, and then the attribute prices for different buyers are used in a second step demand model (Bajari and Kahn 2003, Ekeland; Heckman and Nesheim 2004). Another way to find variation in prices is to use information from multiple markets assuming that consumers in each market share a common preference structure. This method was first suggested by Brown and Rosen (1982) and has been used by Palmquist (1984), Bartik (1987), Zabel and Kiel (2000), and Kristofersson and Rickertsen (2004).

In relation to fish markets, Kristofersson and Rickertsen (2004)) use the Brown and Rosen model to estimate hedonic inverse input demand for Icelandic cod. In the first stage, 881 trading days in the Icelandic fish auctions are used to estimate hedonic prices for different sizes of cod, non-gutted cod and storage time. In the second stage, input demands for these attributes are estimated. The results show that price changes are small as a response to increased quantities of the size attributes. The price changes are larger when the quantities of the attributes non-gutted and storage increase. The study also shows that the attribute prices of larger sizes have increased more over time than smaller sizes.

Another problem that has caused much debate concerning the hedonic demand function is that unobserved demand characteristics can affect the choice of product attributes (Bartik 1987, Epple 1987). In a fish market context this translates into processor characteristics affecting the choices of

[2] The Marine Stewardship Council is a non-profit organization with a certification program that recognizes and rewards sustainable fishing.

quantities of fish with different attributes. For example, it might be the case that processors with fillet machines have a demand for fish of a certain size that fit in the machine, or there could be buyers of fish that sell to luxury restaurants with a demand for fish of higher quality.

One way to find variation of prices and solve the problem of unobserved demander characteristics is to use daily observations of the hedonic price function under the assumption that this function varies from day-to-day, but that unobserved characteristics of the processors do not. This allows the estimation of hedonic price functions that are unaffected by processor characteristics.

2.4 Estimation

In this study fishers are assumed to be price takers in the short run. The assumption seems especially motivated for daily supplies. When fishers have landed the catch, the attributes of the fish cannot be changed. It is also assumed that unobserved processor characteristics do not vary from day-to-day. Thus, on a daily basis, the prices of fish attributes are determined by the demands of fish processors. The details of the theoretical framework underlying the model used in this study is described in Kristofersson and Rickertsen (2004) and Kolstad and Turnovsky (1998).

The estimation follows the approach of Kristofersson and Rickertsen (2004) where the hedonic inverse demand equation is estimated using a random coefficient model. The motivation for using this model is that there is a need to take the importance of each landing day into account. For comparison, as in Kristofersson and Rickertsen (2004), the Brown and Rosen (1982) model, which relies on an underlying assumption that estimates from each landing day have the same level of accuracy, is used. The Brown and Rosen model is estimated in two steps whereas the random coefficient model is estimated in one step.

Starting with the Brown and Rosen model, the hedonic equation is estimated for each trading day in a first step. Then the inverse demand equations of the attributes are estimated in the second step using the estimated hedonic prices from the first step. That is, for each landing day t we have:

$$p_{nt} = \boldsymbol{z}'_{nt}\boldsymbol{\beta_t} + \varepsilon_{nt} \tag{3}$$

where real prices[3] on each trading day (t) are regressed on the attributes z. The first stage equation gives the attribute prices on each trading day. The second stage inverse demand functions for each attribute are then estimated as:

$$\boldsymbol{\beta_t} = \boldsymbol{\gamma} + \boldsymbol{\delta}'\boldsymbol{q_t} + \boldsymbol{\theta}'\boldsymbol{t} + \boldsymbol{u_t} \tag{4}$$

where the coefficients from the first-stage models are used as dependent variables, $\boldsymbol{\delta}$ are price effects in SEKs of increasing the quantity of fish with different attributes and q_t are quantities of fish with a certain attribute on trading day t divided by monthly imports. Monthly imports are used as a numraire in order to impose homogeneity[4] and t is a time trend. The second stage coefficients are

[3] Prices are deflated by 1997 consumer prices in order to account for macro-economic fluctuations.

[4] Imports are important to Swedish processors since the supply from Swedish fishers is uneven and of varying quality. Morf, Andrea, Lena Giffperth, Anders Grimvall and Eva-Lotta Sundblad (2012). Fallstudie: Selektivt uttag av torsk - för samhällsanalys i inledande bedömningen i havsmiljöförordingen. Havsmiljöinstitutets rapportserie.

interpreted as own-quantity effects and cross-quantity effects. The own-quantity effects show how much a certain attribute price is affected by a change in the quantity supplied of that attribute, whereas the cross-quantity effects show the effects of changing quantities of other attributes on the price of a certain attribute. Symmetry is imposed a priori on the system, which reduces the number of cross-quantity effects to be estimated. Furthermore, quantity effects are normalized to facilitate interpretation; the coefficients can then be interpreted as the fall in price in SEK if the quantity of an attribute increases by 100 percent. Finally, the trend variables are adjusted so that the coefficients accompanying them can be interpreted as yearly effects.[5]

Using the Brown and Rosen two-stage method, the two steps are estimated separately. As mentioned above, the problem with this model is that it gives equal weight to the estimates from each trading day. Hence, the main focus in this study is on the random coefficient model, i.e. the two steps are estimated simultaneously by inserting the second equation into the first equation (as in Kristofersson and Rickertsen (2004)):

$$p_{nt} = \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\gamma} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\delta'}\boldsymbol{q_t} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\theta'}\boldsymbol{t} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{u_t} + \varepsilon_{nt} \qquad (5)$$

The first part of the equation, $\boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\gamma} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\delta'}\boldsymbol{q_t} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\theta'}\boldsymbol{t}$, is the fixed part and the second part, that is $\boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{u_t} + \varepsilon_{nt}$,, is the random part. The estimation will contain main effects, $\boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\gamma}$, as well as cross-level interaction effects, i.e. $\boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{q_t}$. The coefficient of the interaction terms involving $\boldsymbol{q_t}$ will be the quantity effects of the model. Assuming that the time effects are attribute-specific results in them being specified as interactions in the model. The same restrictions regarding homogeneity and symmetry as in the Brown and Rosen model are used, as is the same normalization of the q-variables. Additionally, the covariance's of the $\boldsymbol{u_t}$:s are included in the model, which results in the model being estimated with twelve random effects terms.[6]

More specifically, the random coefficient model assumes that each landing day has different slope coefficients, and that the variation of these coefficients can be explained by the *q*-variables (and a time trend). This means that the relationship between the kilo price of cod and the attributes of cod depend on the quantities of different attributes that are traded. The quantities purchased thus act as moderator variables for the relationship between price and attributes where the relationship varies according to the value of the moderator variables (i.e. the quantities purchased on a certain day). The coefficients, $\boldsymbol{\gamma}$, $\boldsymbol{\delta}$ and $\boldsymbol{\theta}$ are fixed coefficients since they apply to all landing days. All between-days variation that is left in the $\boldsymbol{\beta}$ coefficients, after predicting using these coefficients, is residual error variation indicated by $\boldsymbol{u_t}$.

2.5 Data

Data on values and quantities of landings of cod by Swedish vessels in Swedish Baltic ports for the period 1997-2011 is available from the Swedish Agency for Marine and Water Management. Price per unit of cod can thus be calculated for each observation. In addition, quality ratings (Class E, A or B) and size classes (1-5) of the observations are included. There is a total of 731 540 observations in the database used in this study. The data is collected from sales notes that are sent from fish

[5] In practice, the trend variable has been divided by 365.

[6] A log-ratio test of the model with covariance terms (unconstrained model) versus the model with only variance terms (constrained model) indicates that the model with covariance terms is the preferred model.

receivers to the Swedish Agency for Marine and Water Management. All primary receivers of fish are required to register and report to the Agency (European Commission 2009), and the database thus includes all cod that is reported as sold in Swedish Baltic ports. For each observation the following is reported: the amount landed, the price paid for the fish, the id-number of the vessel, the size class of the landing, the quality class of the landing, the port where the landing was registered, the id-number of the buyer and the date when the landing arrived. As mentioned above, imports are used as a numraire when estimating the inverse demand function. The data on imports of fresh and chilled cod[7] to Sweden is available on the Statistics Sweden homepage, which shows that imports have increased over the time period. Some summary statistics, together with data on Swedish quotas, are presented in Table 1.

Table 1: Summary statistics: Baltic cod catches from Swedish vessels 1997-2011.

	Number of observations	**Number of vessels**	**Quantity Landed (tons)**	**Swedish quota* (tons)**	**Price per kilo (SEK)****
1997	65 848	612	22 093	38 860	9.6
1998	58 599	563	14 024	29 246	13.2
1999	64 356	536	14 134	25 870	13.8
2000	68 005	546	16 154	21 303	13.9
2001	69 218	517	16 286	22 083	14.9
2002	55 043	476	12 378	15 203	14.9
2003	58 297	440	12 332	15 438	12.5
2004	53 852	408	12 697	12 323	12.2
2005	46 567	391	8 892	12 918	13.8
2006	42 168	350	10 243	14 969	14.2
2007	33 090	323	10 427	13 649	14.5
2008	35 933	320	9 311	12 011	13.9
2009	32 399	276	9 892	12 916	10.6
2010	24 760	237	9 564	14 685	11.1
2011	23 467	228	10 258	16 645	11.1

**Quotas as set by the original EU regulations setting quotas each year, i.e. amendments are disregarded.*

*** Deflated by 1997 consumer prices.*

The total number of observations in 2011 was only 36 percent of the total number of observations in 1997. The decrease in observations is accompanied by a decrease in the number of vessels and a decrease in the quantity of cod landed, which in turn is related to the decrease in quotas for the Swedish Cod Fishery. For example, the national quota for Sweden, which was 38 860 tons in 1997, had decreased to 12 011 tons by 2011 (European Commission 1996a, European Commission 2010). In 2011 the number of vessels landing cod was less than half (38 percent) of the number of vessels in 1997. A further look at the data reveals that the decrease in the number of vessels is due to a decrease in the number of vessels using passive gear. The share of the total quantity landed by vessels using active gear was around 60 percent in 1997, which had increased to more than 80 percent by the end of the time period (own calculations). Table 1 also displays the average price of cod over the time period and shows that the price of cod is negatively correlated with landed

[7] Fresh and chilled cod has the CN-number 030250 according to the Combined Nomenclature of tariff lines used in the European Union.

quantities. The highest average prices were recorded in 2006-2008 when Swedish fishers received around 16 SEK (around 14 SEK in 1997 prices) for a kilo of cod. The average price has since declined.

Prices are related to size and quality and therefore a change in the composition of landings could hide the effect that different characteristics have on average prices. Size classes and quality ratings are regulated by the European Commission in a regulation that lays down common marketing standards for certain fishery products (European Commission 1996b). The five size classes for cod are: 0.3 to 1 kilo, 1 to 2 kilos, 2 to 4 kilos, 4 to 7 kilos and more than 7 kilos. The quality classes are determined on the basis of the freshness of the fish and are the same for all whitefish. To be classified in category E, the fish must be free of pressure marks, injuries, blemishes and bad discoloration. For category A, the fish must be free of blemishes and bad discoloration. A very small proportion with slight pressure marks and superficial injures can be tolerated. Finally, for category B, blemishes and bad discolorations are not tolerated, but a small proportion with more serious pressure marks and superficial injuries is accepted. Further definitions of the categories are specified in the regulation where special ratings are based on the skin, skin mucus, eyes, gills, peritoneum (in gutted fish), smell of gills and abdominal cavity and flesh. For ease of presentation the quality classes are referred to as Class A, Class B and Class E in the following.

Figure 1 presents shares of cod with different attributes in total landings. The two largest size classes (>4 kilos) have been added together since they represent small shares of the total quantity landed. Only around 1-3 percent of the cod weigh more than 4 kilos. Between 5 and 10 percent of the landings of cod weigh between 2 and 4 kilos, whereas most of the cod landed are smaller than 2 kilos since more than 90 percent are classified into one of the smaller size classes. The most notable change during the time period is the increase of landings of very small fish. Cod weighing between 1-2 kilos become more unusual and cod weighing 0.3-1 kilos constitute almost 60 percent of landings by the end of the time period.

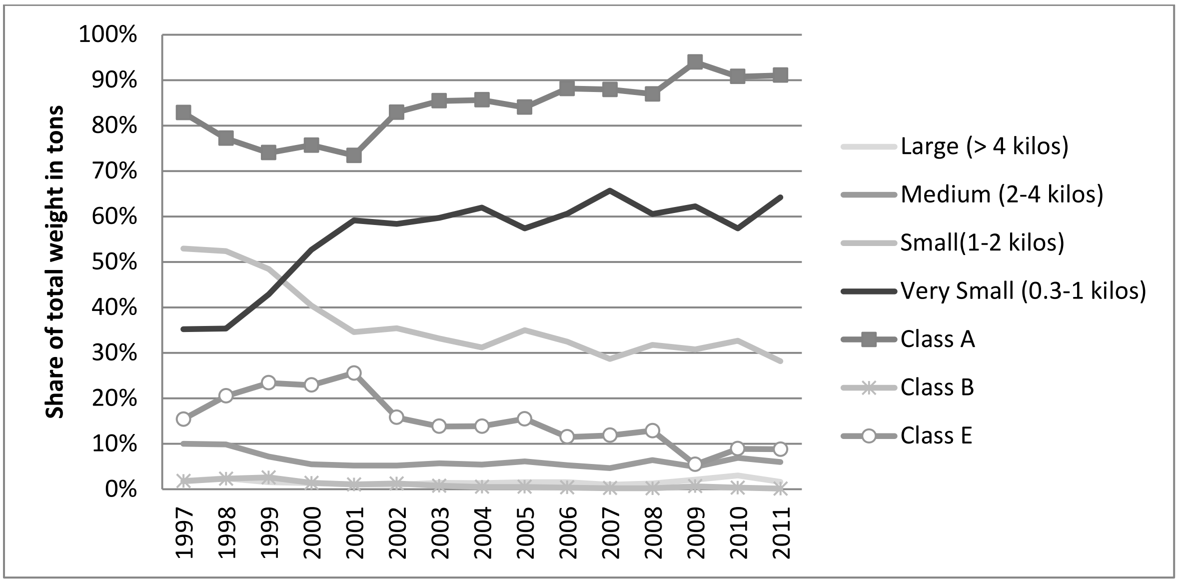

Figure 1: Shares of quantities (tons) of cod with different characteristics (1997-2011)

The quality ratings outlined in the EU regulation result in most fish being classified as of average quality, i.e. Class A. A varying amount of fish is classified as Class E, that is, the finest quality available in the EU classification; over the years this share ranges between 5 and 25 percent. A very small share of the fish is classified as Class B, i.e. below average quality. The trend is towards more fish being classified as Class A. In summary, the data show that cod landed in Baltic Swedish ports have decreased in quality as well as in size.

Figure 2 presents the real prices of cod with different characteristics. Real prices increase for almost all types of cod except for cod in Class B until 2007. Since then, real, as well as nominal, prices have decreased. Comparing cod of different characteristics, it appears that Class B has considerably lower prices than the other classes, and that the price of cod in this class decreases over time. Most of the cod landings in Swedish Baltic harbours are classified as Class A and the price of this class is therefore close to the average price during the time period. The price of Class E cod follows the price of Class A cod closely until 2008 when a price premium of Class E cod appears.

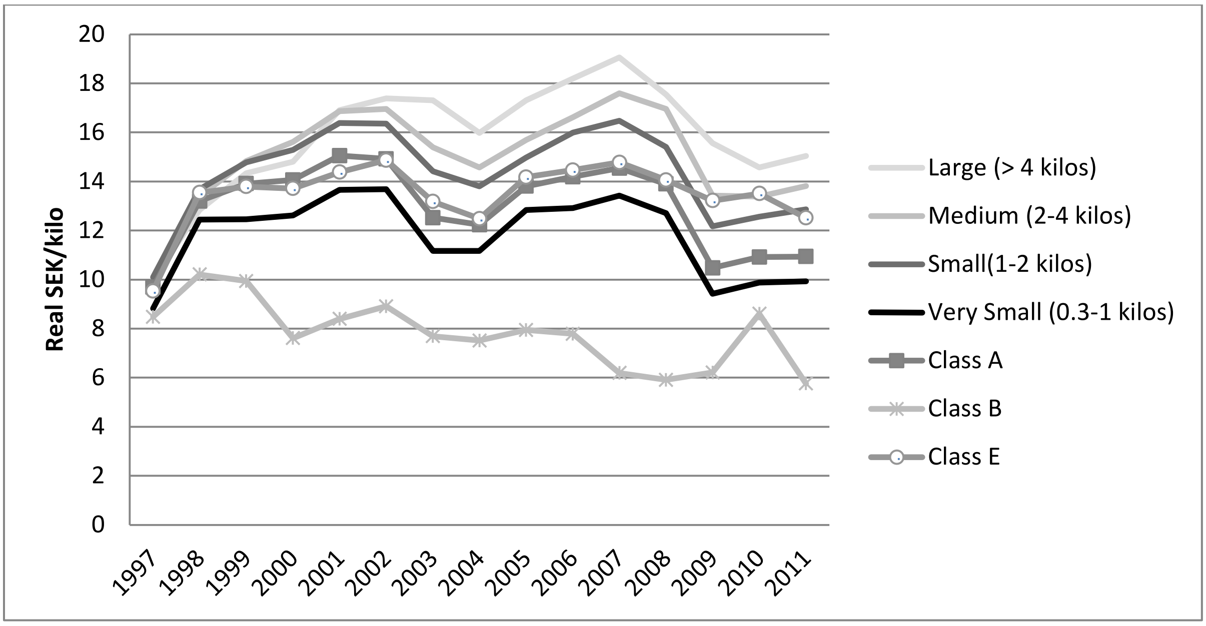

Figure 2: Prices of cod with different characteristics (1997-2011), SEK/kilo*

**Deflated by 1997 consumer prices from Statistics Sweden.*

Looking at the prices of cod of different sizes, it is apparent that larger sizes have higher prices. However, it appears that the smallest size category (Very Small) has substantially lower prices than the other size categories. Another interesting observation is that the prices of different categories of cod appear to be more similar in the beginning of the time period, and diverge more towards the end of the time period. This is an indication that different attributes of cod have become more important over time.

The inverse demand model uses information on daily attribute prices and landed quantities to estimate the effect of quantity changes on attribute prices. Hence, it is important that prices vary from day to day. An example of the variation of prices is shown in Figure 3 where prices (in SEK per kilo) vary considerably between days in 2011. The diagram shows that prices, as before, are lower for the very small cod (0.3 to 1 kilo). The price difference between the other sizes is more difficult to observe in the diagram, although it is clear that the smaller cod (1-2 kilos) vary less in price than cod in the two largest size categories.

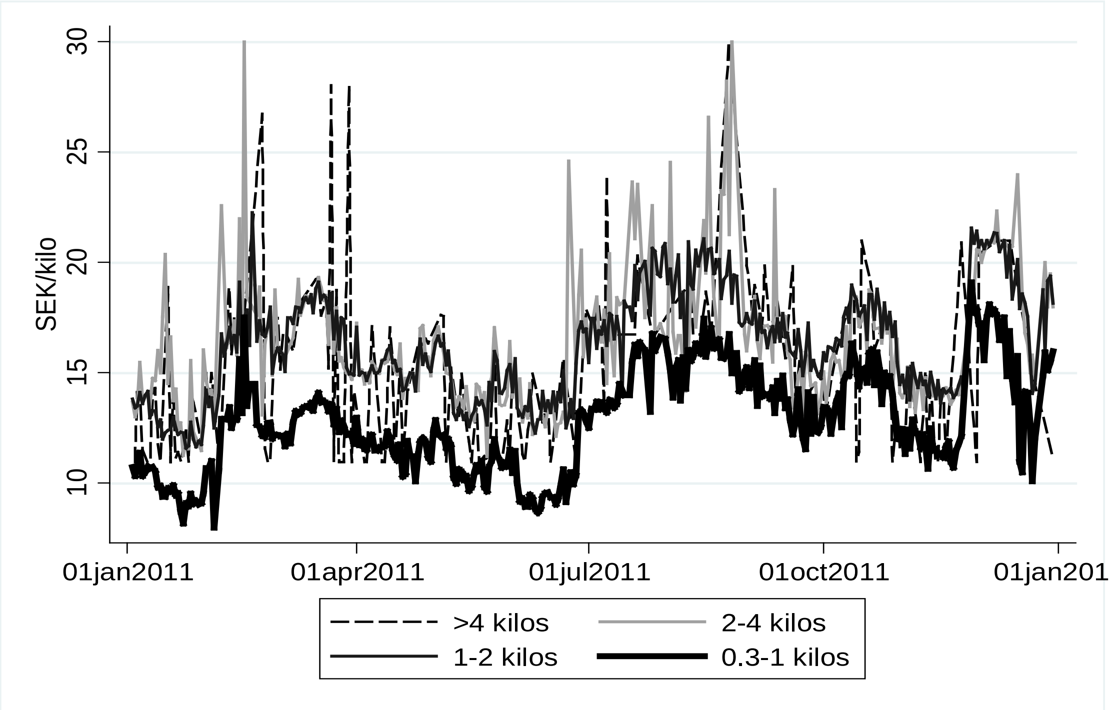

Figure 3: Day-to-day variation of prices of Class A cod landed in the Baltic in 2011.

Note: Price observations that are larger than 30 SEK or smaller than 1 SEK have been omitted from the diagram in order to get a clearer picture. A total of 1394 observations are lost, which is only 0.002 percent of the total number of observations in the dataset.

The diagram also reveals seasonal patterns; the price is higher in late summer and lower in the beginning of the year. Running a regression of monthly dummies in a simple hedonic model shows that a similar pattern occurs during the entire time period. This regression also shows that the price is highest in October and lowest in May.[8]

Table 2 summarizes the variables used in the regressions. In the first stage of the Rosen-Brown model $\boldsymbol{p_{nt}}$ is regressed on six dummy variables (z-variables). In the second stage the estimated marginal prices of the first stage are used to estimate the inverse demand functions using the quantity variables and the time variables defined in Table 3. In the random coefficient model all variables are estimated in one step.

[8] The results are available upon request.

Table 2. Definition of variables.

Variable	Definition	Mean
p	Real price per kilo of each landing in SEK	14.26
z_L	Dummy variable, 1 for Large(>4 kilos)	0.05
z_M	Dummy variable, 1 for Medium (2-4 kilos)	0.18
z_S	Dummy variable, 1 for Small(1-2 kilos)	0.41
z_VS	Dummy variable, 1 for Very Small(0.3-1 kilos)	0.36
z_B	Dummy variable, 1 for Class B	0.04
z_E	Dummy variable, 1 for Class E	0.2
qL	Total quantity of Large cod, tons per day	0.56
qM	Total quantity of Medium cod , tons per day	2.25
qS	Total quantity of Small cod, tons per day	13.48
qVS	Total quantity of Very small cod, tons per day	19.36
qB	Total quantity of Class B cod, tons per day	0.40
qE	Total quantity of Class E cod, tons per day	5.10
qIM	Total quantity of imports fresh and chilled cod, tons per month	521
tr	Trend	
Constant	Constant	

2.6 Results

Hedonic real prices are presented in Table 4 which shows the results of an OLS regression using all observations, the average of the coefficients from the first stage of the Brown and Rosen model and the sum of the coefficients of the dummy variables of attributes ($\boldsymbol{z'_{nt}}$) and the interaction coefficients ($\boldsymbol{z'_{nt}\delta' q_t}$) at average quantites in the random coefficient (RC) model[9]. Since the model is run without a constant and all the size variables are included, the coefficients of the size variables show the average prices of cod for each size in quality class A. The coefficients of the quality attributes (Class E and Class B) show the price premia of supplying a product of better or worse quality.

[9] Here the RC model is estimated without a time trend in order to get average values comparable with the OLS and Brown and Rosen models. The full results of the RC model are available upon request.

Table 3. Attribute prices

	OLS	Average of β-coefficients of BR model	Hedonic prices from the RC-model at average quantities
z_L	14.97***	15.69	15.61
z_M	14.22***	14.89	14.76
z_S	14.22***	14.64	14.52
z_VS	11.60***	11.95	11.83
z_B	-5.89***	-6.41	-6.37
z_E	1.26***	1.27	1.04

*Note: No of observations in OLS and RC-model is 731 540. No of regressions in first stage of RB-model is 5307. Significant levels are * for p<0.05, ** for p<0.01, and *** for p<0.001 for the OLS model.*

All models show the same pattern and have similar coefficients. Since the number of observations is much larger in the beginning of the time period the price differences in the OLS model reflect the situation in the beginning of the time period to a larger extent than the other models (compare Figure 2). The Brown and Rosen model shows the average of the coefficients from 5307 landing-day regressions and hence accords each landing day equal importance. Since price differences increase over the time period (see Figure 2) the higher prices of Medium and Large cod as compared to OLS is not surprising. Finally, the RC model, which includes all the interaction terms (except the trend interactions) and random error terms in equation 5, give attribute prices that are very similar to the BR-model.

Using the results from the RC model, the real price difference between Very Small cod and Small cod is 2.69 SEK. The difference between the real prices of other size classes is smaller; the difference between Small and Medium cod is only 0.25 SEK on average over the time period using the RC model results. Large cod has a somewhat higher price premium; the price of Large cod is 0.85 SEK higher than the price of Medium cod according to the RC model. The effect on price of increased quality, i.e. the change from Class A to Class E, increases the price of cod by 1.04 SEK using the RC model. Class B cod, on the other hand, generates significantly lower prices than Class A or Class E cod in all models. This suggests that Class B cod is of significantly lower quality than Class A cod.10

The results of inverse demand from the RC model, i.e. the coefficients of the interaction variables in equation 5 above, are presented below.[11] The coefficients are interpreted as the effect on price of a hundred percent increase in the quantities of different attributes, as compared to the mean quantities (see Table 2). On average 37 tons of fish is traded on a typical day during the time period, although the variation is large.

[10] Testing the coefficients on the $\boldsymbol{z'}_{\boldsymbol{nt}}$- variables of the size attributes show that these coefficients are significantly different from each other in the RC model.

[11] Estimated using the xtmixed command in STATA.

Table 4. Results of inverse demand from the RC model: marginal effects of quantity changes.

	z_L	**z_M**	**z_S**	**z_VS**	**z_E**	**z_B**
qL	**-0.1872*****	-0.1189***	-0.1055***	-0.0987***	0.0133	0.0675***
qM	-0.1189***	**-0.1708*****	-0.1477***	-0.01	-0.0006	0.0709***
qS	-0.1055***	-0.1477***	**-0.1758*****	-0.0805***	0.0211	0.0708***
qVS	-0.0987***	-0.01	-0.0805***	**-0.2923*****	0.0027	0.0508***
qE	0.0133	-0.0006	0.0211	0.0027	**-0.1055*****	-0.0144
qB	0.0675***	0.0709***	0.0708***	0.0508***	-0.0144	**-0.0184**
tr	0.1943***	0.0703***	0.0003	-0.0670***	0.1385***	-0.1452***

*Note: The number of observations are 731 540. Significant levels are * for p<0.05, ** for p<0.01, and *** for p<0.001.*

Most coefficients are significant and have the expected sign. The own-quantity effects are as expected; increasing the amount of Large, Medium, Small, Very Small and Class E cod gives lower prices of these attributes. The effect of increasing the amount of cod in Class B on the price premia of Class B cod is not significant. B-cod has a substantially lower price than other types of cod, and the number of observations is small (see Table 1 and 2). The own-quantity effect is largest for the Very Small cod (0.3-1 kilo); when the quantity of very small cod doubles, the price decreases by 0.29 SEK. The own-quantity effects of the other size attributes are very similar, and the results indicate that the price decreases by 0.17-0.18 SEK on average when quantities increase by 100 percent. This suggests that increasing the weight of cod to more than 2 kilos would not affect prices substantially. However, the relatively small price premia on larger sizes of cod might discourage fishers from aiming for cod larger than 2 kilos. One possibility is that this is a short-term effect due to processors being restrained by current technology. If the supply of larger sized cod was to increase substantially, technology could also change and prices would increase for larger sizes of cod. An increase of the amount of Class E cod in the market does not affect price as much as increases in the size attributes, indicating that demand for Class E cod is relatively insensitive to quantity changes.

Cross-quantity effects are negative between the size attributes, indicating that different sizes are substitutes. Cross-quantity effects are significant in all cases except between Very Small and Medium cod. There is also some indication that when cod are closer in size, the effect of quantity changes on price is larger; for example, if the quantity of Medium and Small cod increases by the same amount, the price of Large cod will be more affected by the increase of Medium cod. The price of Medium cod also seems to be more affected by quantity changes in Large and Small cod than by quantity changes of Very Small cod. In fact, Very Small cod does not seem to be affected much by quantity changes in substitute attributes at all.

The cross-quantity effects of Class E and Class B cod are positive in most cases, although insignificant for Class E cod. Increasing the amount of Class E cod does not seem to affect the prices of other attributes than the price of Class E cod itself. However, increasing amounts of Class B cod increase the price of all the size attributes, indicating that larger amounts of low quality cod increase the value of average quality cod.

The coefficients for the trend variables show that, over time, Class B cod and Very Small cod are less preferred, while and Class E cod and Large cod are more preferred. On average, the price of Class E cod increases by 0.14 SEK per year, and the price of Large cod increases by 0.19 SEK per year. Also, the price of Medium sized cod is increasing, although a bit less, over time. The pattern is similar to

Kristofersson and Rickertsen (2004), who find a trend in demand away from bad and towards better quality cod over time.

The variance components of the RC model are shown in the appendix (Table A2). All components are significant. The estimates show that the variability of attribute prices is larger the larger the cod, and larger for cod in quality Class B. The variability of the size attributes confirms the picturein Figure 3. The results from the Brown and Rosen model are also shown in the appendix (Table A1). These results are similar to the results presented above: own-quantity effects are negative, cross-quantity effects are smaller and give an indication of whether attributes are substitutes or complements. As in the RC model, time trends indicate that larger andbetter quality cod is valued more over time. However, the coefficients are smaller in magnitude and the number of coefficients significant on the 0.1 percent level is smaller. The results from the RC model thus seem to be more robust. Finally, since landings of cod from different ports are used in the estimation of the inverse demand equation, it is possible that specific port effects could influence the quantity effects. However, running a regression where random effects of ports are included does not change the estimated coefficients significantly (see appendix and Table A3 for a further discussion).

2.7 Discussion and policy implications

An interesting aspect of the Swedish Baltic Cod Fishery is that both fishermen and researchers are looking for methods to increase the size of Baltic cod. For example, the Swedish Association of Cod Producers is aiming at increasing the minimum size of landed cod to 40 cm (STPO Action Plan 2012). In addition, as mentioned above, increasing the size of the Baltic cod has also been suggested as desirable by a number of biological studies. One of the most important expectations of increasing the cod size is that it will generate higher revenues to fishermen[12]. Thus, the effects of quantity changes on attribute prices could be used to indicate how revenues change as the composition of landings change.

Cardinale and Hjelm (2012) estimate revenues from changing the size range of Eastern Baltic cod by introducing methods for size selectivity (i.e. regulating gear mesh size). The optimal scenario is when the cod that is harvested has reached a length of 70-77 cm and is 5-6 years of age. This cod would be of medium size, weighing between 2 and 4 kilos, according to the definition used above.[13] Two different price scenarios are used in Cardinale and Hjelm (2012), where prices are assumed to be either the same for all sizes or vary between sizes such that the largest cod is 65 percent more expensive than the smallest cod. These prices are based on Swedish cod prices in 2010. Initially size selective harvesting would result in a loss, since there are currently few large cod in the population. However, the authors conclude that revenues would increase in the long run and would be higher than under the current management plan within five years. Prices in the study are unrelated to other quality attributes or changes in quantities.

[12] Although it could theoretically be possible that costs per unit increase when catching larger fish, it is not a realistic assumption since the inputs of fishermen (boats, nets, fuel consumption) are likely to be the same for different sizes of fish.

[13] The length-weight relationship is approximate and based on personal information given by the Swedish Institute of Marine Research 2013-04-22, Hans Nilsson.

Froese; Stern-Pirlot; Winker et al. (2008) investigate how size selective fishing in the Western Baltic can increase the biomass more than under the management regime proposed by the European Commission, which aims at the maximum sustainable yield of the fisheries. An age structure that is similar to an unfished stock could give the same yield as in the EU management regime. The optimal size of cod is then 80 cm, which would be equivalent to cod in the largest size category, Large, in the dataset used above.

Considering that only 10 percent of the cod catch consisted of cod larger than 2 kilos on average during 1997-2011, the optimal scenarios in the biological studies above are far from today's situation. One challenge when using the coefficients from the RC model is that it is difficult to extrapolate to compositions of landings that differ from those observed during the time period studied. However, by experimenting with the quantities caught of different size attributes, we can move in the direction of the optimal scenario. An attempt to do so is presented below. The results have to be interpreted with caution.

To simplify, we assume that the total quantity does not change and that all cod is Class A. Then, assuming that cod weighing less than 1 kilo is no longer fished, perhaps because of a mesh size regulation, the revenues from Very Small cod will disappear. Initially, as discussed by Cardinale and Hjelm (2012), total revenues will decrease. But eventually the Very Small cod that are left will grow and become larger in size. Assuming that all cod that are caught have grown into the next size category, the quantities of Large, Medium and Small cod will increase and attribute prices will decrease. The effects of this experiment on revenue are shown in Table 5 where the new revenue is also compared to the old revenue and the expected revenue without taking into consideration quantity effects.

Table 5. Experimenting with the coefficients from the RC model (see text for details).

	p_L	**p_M**	**p_S**	**p_VS**	
Price in 2011 at average quanitities	***18.511***	***15.733***	***14.341***	***10.653***	
Price change because of change in qVS	0.000	0.000	0.000	**0.000**	
Price change because of change in qS	-0.046	-0.065	**-0.077**	-0.035	
Price change because of change in qM	-0.592	**-0.850**	-0.735	0.000	
Price change because of change in qL	**-0.757**	-0.481	-0.427	-0.399	
Total price change	**-1.395**	**-1.395**	**-1.238**	**-0.434**	
Price of new quantities	***17.116***	***14.337***	***13.102***	***10.219***	**Total revenue**
Revenue in SEK	48 136	193 211	253 685	0	495 032
Initial revenue in SEK	10 323	35 471	193 261	206 265	445 320
Unadjusted revenue in SEK	52 058	212 014	277 662	0	541 734

Using the calculated attribute prices from the RC model for 2011 as the initial prices, the price changes from quantity changes of different attributes are calculated. The new attribute prices are lower for Large, Medium and Small cod. In this case, the price of Large and Medium cod is affected more than the price of Small cod. This is because the percentage quantity changes are much larger for Medium and Large cod. However, despite the lower prices, the last column to the right shows that the average revenues per day increase in the new situation. This is due to the shift away from Very Small cod that have lower prices. The last column also shows that total revenue is lower when using the coefficients from the inverse demand model than if unadjusted prices are used as in Cardinale and Hjelm (2012). Using unadjusted prices results in an overestimation of approximately 47000 SEK or a 10 percent increase of the initial revenue.

Several studies (Quaas; Requate; Ruckes et al. 2010, Diekert 2011, Ravn-Jonsen 2011) conclude that TACs and tradable quotas, measured in terms of biomass, will fail to solve the problem of growth overfishing, i.e. the situation when fish are caught at an inefficiently low age and weight class. The solution would be to measure the TACs and tradable quotas in terms of number of fish[14]. An underlying assumption in studies on growth overfishing is that the revenues of fishermen increase when larger sized fish are landed. Here, we have shown that prices are higher for larger sized cod than for the smaller cod, and that prices will not decrease substantially when the amount of larger cod increases on the market. Hence, there will be incentives for fishermen to aim for larger sizes of cod if quotas are set in numbers of fish rather than in quantities. Furthermore, the time trends in this study show that larger sizes and better quality fish have become more valuable over time.

2.8 Conclusions

This study uses a random coefficient model to estimate the attribute prices and inverse demand of Baltic cod landed in Swedish ports in the period 1997-2011. A detailed dataset makes it possible to use daily observations of cod landings in different size and quality rating classes. The results show that there is a price difference of 2.69 SEK between cod weighing 0.3-1 kilo and cod weighing 1-2 kilos. Looking at larger sizes of cod, price premiums are increasing less per kilo added. The price difference between cod weighing 1-2 kilo and cod weighing 2-4 kilo is only 0.25 SEK. The largest cod in this study, defined as weighing more than 4 kilos, are on average 0.85 SEK more expensive than the 2-4 kilo cod.

Looking at the quality ratings, there is a clear indication that cod classified as Class B is of inferior quality. Prices are much lower than for the most common quality rating, Class A. However, the highest quality class, Class E, generates only somewhat higher prices (a price premium of 1.04 in the random coefficient model) than Class A cod.

The results of inverse demand show that own-quantity effects are negative for all attributes and cross-quantity effects are negative between size attributes, indicating that size attributes are substitutes. This means that when the quantity of cod with a certain attribute increases, attribute prices of that particular attribute decrease, as do prices of other size attributes. The largest own-quantity effect is for the smallest cod in the sample; when the quantity of small cod increases by 100 percent, the price decreases by 0.29 SEK. The own-quantity effects of the other size attributes range between 0.17 and 0.18 SEK. Over time, the results suggest that the prices of larger cod and cod with the highest quality rating are increasing.

The management system chosen for a particular fishery will affect the size and quality composition of fish landed. A management system that increases the size and the quality of landed fish will face the law of demand; as the quantity of attributes increase, prices will decrease. This chapter has shown that the price effects of increasing quantities of attributes are moderate, but nevertheless too

[14] The same effect could of course arise if mesh size was increased by regulation, but the cost of monitoring would be higher for society.

important to ignore. Thus, when the revenues of future management systems are modeled, the price effects of attributes should be taken into account.

2.9 Appendix

The Brown and Rosen model

The results from the second stage inverse demand functions of the Brown and Rosen model are presented in Table A1. The price premiums of each attribute from the first stage models are used as dependent variables in the regressions, together with a time trend. The equations are estimated as a system[15], which is reasonable since error terms might be correlated across the equations. For example, what influences prices of large fish on a certain day will also influence prices of small fish on that day. The system is also estimated with the same homogeneity and symmetry restrictions used in the RC model.

Table A1. Results from the second stage inverse demand Brown and Rosen model (system estimation)

	z_L	z_M	z_S	z_VS	z_E	z_B
qL	**-0.0659*** **	-0.0343**	-0.0345***	-0.0303**	0.0072	0.0105
qM	-0.0343**	**-0.0694*** **	-0.0566***	0.003	-0.0021	0.0159*
qS	-0.0345***	-0.0566***	**-0.0830*** **	-0.0199*	0.0186**	0.0180**
qVS	-0.0303**	0.003	-0.0199*	**-0.1229*** **	-0.0016	0.0101
qE	0.0072	-0.0021	0.0186**	-0.0016	**-0.0342** **	-0.0032
qB	0.0105	0.0159*	0.0180**	0.0101	-0.0032	**0.0038**
tr	0.3541***	0.1553***	0.0531***	-0.0349**	0.1432***	-0.1922***
Constant	13.7495***	14.0660***	14.4054***	12.2432***	0.0736	-5.2652***

*No of regressions in first stage of BR model is 5307. Significant levels are * for p<0.05, ** for p<0.01, and *** for p<0.001.*

The results, when significant, are of the expected sign. Similar to the RC model, the own-quantity effects (in bold) are negative for the prices of Large, Medium, Small, Very Small and Class E and, looking at the size prices, the largest effect of increasing the quantity is on the very smallest fish. Additionally, similar to the RC model, the own-quantity effect of Class E cod is smaller than the own-quantity effects of the size attributes.

Variance component estimates of the RC-model

The variance components of the RC model are shown in Table 7. All components are significant. The estimates show that the variability of attribute prices is larger the larger the cod, and larger for cod in quality Class B. The variability of the size attributes confirms the picture in Figure 3.

Table A2. Variance component estimates of the RC model

Variable	Estimate
z_L	3.5865
z_M	2.8765
z_S	2.7253
z_VS	2.4502
z_E	1.2781
z_B	2.5960

[15] Using the surreg command in STATA.

The random coefficient model with port effects

Since landings are in 157 different ports along the coast, there is a possibility that prices differ in different landing places. In order to control for port effects, a regression, as specified below, with random port effects has been run:

$$p_{nt} = \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\gamma} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\delta'}\boldsymbol{q_t} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{\theta'}\boldsymbol{t} + \boldsymbol{z'}_{\boldsymbol{nt}}\boldsymbol{u_t} + \delta_{nt} + \varepsilon_{nt} \qquad (6)$$

where the term $\boldsymbol{\delta_{nt}}$ has been added to equation 5 to include an intercept for port effects. The results are shown in Table A3 below.

Table A3. Results from a random coefficient model with port effects

Variable	Coefficient
z_E	-0.1084*
z_B	-5.7644***
z_M	14.6758***
z_S	14.8963***
z_VS	12.6440***
z_L	14.7068***
int_zE_tr	0.1660***
int_zB_tr	-0.1364***
int_zVS_tr	-0.0823***
int_zM_tr	0.0520***
int_zS_tr	-0.0164
int_zL_tr	0.1700***
intz_EqE	-0.1090***
intz_BqB	-0.0265
intz_MqM	-0.1802***
intz_SqS	-0.1779***
intz_VSqVS	-0.2902***
intz_LqL	-0.1970***
intEM	0.0042
intES	0.0249*
intEL	0.011
intBE	-0.0138
intBM	0.0735***
intBS	0.0725***
intBL	0.0690***
intMS	-0.1486***
intML	-0.1226***

*Note: The number of observations is 731 540. Significant levels are * for p<0.05, ** for p<0.01, and *** for p<0.001.*

In general, the results are very similar to the results of the RC model without port effects. The major difference is that the direct effect, i.e. the attribute price, of Class E cod is now negative and only significant at the 5 percent level.

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3. Time for fishing: bargaining power in the Swedish Baltic cod fishery

3.1 Introduction

Faced with excess capacity and overfishing, fisheries management has largely focused on reducing fleet size and improving ecological conditions. Property rights, such as Individual Transferable Quotas (ITQs), have the potential to reduce capacity and increase profitability in the sector (Andersen et al., 2010; Arnason, 2008; Gómez-Lobo et. al., 2011; Suitinen, 1999; Waldo and Paulrud, 2012). However, the introduction of property rights and the way these are designed might have effects not only on fleet size and thus the cost structure of the fleet, but also on the distribution of rents between fishers and processors in the ex-vessel market for fish (Hackett et al., 2005; Matulich et al., 1995; McEvoy et al., 2009). By studying reform-related price changes it is possible to understand how rent distribution is affected, and why there might be resistance to reforms.

In this chapter, we contribute to the literature by analyzing price formation in the Swedish Baltic Sea cod fishery when the management system changed from quarterly to annual quotas. The new management system introduced more flexibility for fishers since the obligation to land on a quarterly basis was removed.. This could result in landings becoming more irregular if, for example, costs are lower during certain time periods or if alternative fishing possibilities generate higher rents during certain periods. Processors, on the other hand, are reliant on regular landings, since processing capacity is fixed in the short run and hence capital and labor resources might be wasted with more irregular landings. In addition, down-stream markets (i.e. wholesalers and retailers) might be willing to pay more for fish that is regularly delivered. Thus, in the short run, processors might be negatively affected, and concerns about supplies for processors were accordingly raised in the proposal for the new management system (Swedish Board of Fisheries, 2010a). The obligation to land part of the quota each quarter remains from a rationing system with weekly landing obligations imposed to ensure regular landings for the processing industry (County Administrative Board of Skåne, 2005).

The purpose of this chapter is to examine whether the new management system has altered the price formation process in the ex-vessel market. There is considerable dependency between fishers and buyers (processors) on the Baltic Sea coast of Sweden, and both groups operate on markets with limited entry, which implies that there is a bargaining situation on the market. More specifically, as the fishers' flexibility to allocate landings within the harvest season has increased, we hypothesize that the bargaining power of the fishers should improve. To test the hypothesis of increased bargaining power of fishers empirically, we use detailed price data from landing tickets submitted to the Swedish Agency for Marine and Water Management. To identify the bargaining power effect, we utilize the fact that the regulatory change only applied to vessels using active gear (i.e. trawls). Thus, the segment of passive gear (i.e. nets and hooks) is used as a control group, and the effects are operationalized as changes between the two groups. To the best of our knowledge, the quasi-experimental approach used in this study is a novelty in the literature on the relative bargaining power of fishers and processors.

Earlier studies have analysed price effects when introducing new management systems in fisheries, for example Herrman (1996), Hermann (2000), Grafton et al (2000), Alsaharif and Miller (2012) and

Dupont and Grafton (2001). Although the full price effect of a new management system might be interesting as such, it is difficult to determine exactly what factors contribute to such price changes. For example, reform-related price changes can occur if the quality of fish changes, or if fish is landed in certain ports on certain dates when fishing costs are low. Our study investigates the effects of the reform on bargaining power, and focuses on the idea that the reform made it possible to fish at times more suitable for fishers, but perhaps more unsuitable for processors. By looking at this one aspect, i.e., the bargaining power of fishers, the effect of other reform-related price changes can be left out of the analysis.

The quotas for the Baltic cod stocks (the eastern and the western) are set by the EU each year, but within the system member states have great flexibility to allocate national quotas among their vessels. The Swedsih Baltic cod fishery is regulated by non-transferable individual quotas and traditionally, the fishery was regulated by weekly catch rations, i.e. each vessel was allocated a short-term quota lasting for one week and the quota could not be saved for later periods. The aim of the system was to prevent the overcapitalized fishery from landing the entire quota already at the beginning of the year. To protect the small scale fishery the Swedish quota has further been divided since 2007, into one part for the small scale fishery (passive gear) and one part for vessels using active gear. The weekly catch rations were abandoned on 5 April 2010. From this date, vessels using passive gear have been able to operate without catch restrictions (FIFS, 2010). For vessels using active gear, however, the weekly catch rations were replaced by quarterly catch rations. About a year later, 1 April 2011, yearly quotas were introduced for vessels using active gear (FIFS, 2011).

3.2 Data

The database used in this study is provided by the Swedish Agency for Marine and Water Management, and includes information about prices, landed quantities, size classes and quality classes. All fish receivers in Sweden are compelled to send this information to the Swedish Agency for Marine and Water Management. The subset of the dataset used in this study includes cod that was commercially traded in Swedish Baltic harbors between 1 April 2010 and 31 December 2011, i.e. the period after the latest regulatory change that affected both vessel types (active and passive). Vessels using passive gear are vessels using nets and hooks and vessels defined as belonging to the coastal segment, whereas vessels using active gear are bottom trawlers. Some summary statistics from the database are presented in Table 1.

Table 1: Summary statistics: Swedish vessels catching cod between 1 April 2010 and 31 December 2011.

Segment	Landings (number of observations)	Number of vessels	Quantity landed in tons	Average price in SEK	Most important ports
Passive	32 416	197	3 542	13.8	Skillinge, Nogersund, Simrishamn
Active	9 799	49	12 297	13.3	Simrishamn, Karlskrona-Saltö
Total	42 215	244*	15 838	13.4	

*** The total number of vessels is not the sum of active and passive vessels since two vessels changed their status during the time period.**

Table 1 shows the number of landings (i.e. the number of observations) for vessels using active and passive gear. For each landing the following is reported: the amount landed, the price paid for the landing, the id-number of the vessel, the size class of the landing, the quality class of the landing, the port where the landing was registered, the id-number of the buyer and the date when the landing arrived. Vessels using passive gear have more than three times as many landings as vessels using active gear. This is to be expected since vessels using passive gear are generally smaller and thus have smaller storage capacities. There are 197 vessels using passive gear and 49 vessels using active gear included in the dataset. Vessels using active gear also land considerably more cod than vessels using passive gear (12 297 tons compared to 3 542 tons). The average price of cod (all sizes and quality classes) is 13.44 SEK during the time period and passive vessels receive slightly more than active vessels.

The dataset also reveals that the landings of cod are geographically concentrated. The most important ports for landing cod fished in the Baltic are Simrishamn (40 percent of the landed quantity) and Karlskrona-Saltö (25 percent). Vessels using active gear land 79 percent of their cod in these two harbors. The landings by vessels using passive gear are somewhat less concentrated with 50 percent in three ports (Skillinge, Nogersund and Simrishamn).

Taking a closer look at the prices of cod of different size and quality classes, Table 2 reveals that there are price premiums for larger cod and for cod of better quality. Cod in Class E is defined as fish that must be free of pressure marks, injuries, blemishes and bad discoloration. Cod in Class A and B have similar but slightly lower demands on the quality of the product (European Commission 1996).

Table 2: Average prices of cod of different sizes and qualities during the study period.

Size Classes	Class A	Class B	Class E
>7kilos	17.1	13.8	20.1
4-7 kilos	16.0	12.4	19.4
2-4 kilos	15.5	10.4	18.4
1-2 kilos	15.3	9.9	16.6
0.3-1 kilos	11.9	7.8	12.5

Most of the landed quantity (86 %) is Class A and categorized in one of the smaller size classes, i.e. between 0.3 and 2 kilos. The price discount when cod is classified as Class B is substantial, although only a small proportion of the landings is classified in this category (0.2 percent of the landed quantity). On the other hand, the price premium of landings of cod in Class E is not that large, especially not for the smallest size category. Around 9 percent of the landings are in Class E.

The data show that there are differences between segments, and that different qualities and sizes of cod have different prices. Thus, it is important to take these differences into account when estimating bargaining power. This issue will be further discussed in chapter 3.5.

3.3 The imperfect market of fishers and processors

There are good reasons to expect most regulated fisheries and ex-vessel markets to be imperfectly competitive. Fishers are restricted by limited entry programs, TAC restrictions, season length restrictions and technical regulations on equipment, and ex-vessel markets are often restricted by inaccessibility because of geographical remoteness and entry costs of the processing industry. These characteristics of the primary fish market are also relevant for the Swedish cod fishery and are discussed below.

Two regulations are especially important in limiting entry into the fishery. First, all vessels above 8 meters engaged in the Swedish Baltic Sea cod fishery need a special permit. In 2012 permits were given to 249 vessels (Swedish Agency for Marine and Water Management, 2012). Second, because of overcapacity problems the fishery was closed to new entrants between 2008 and 2011 (it was not until 2011 that small scale fishers could seek new permits, (FIFS 2011)).[1] This ban on entry is perhaps the most important regulation limiting competition among fishers.

Rules and regulations can incur fixed costs of entering the processing sector. For example, strict hygienic requirements make it difficult for fishers to sell their catch directly to consumers without making costly investments (Swedish Board of Fisheries, 2010b). Looking at the data, there is clear evidence that the processing industry is characterized by an oligopolistic structure. The majority of the landed volume is bought by a handful of large agents, indicating that the Swedish cod processing sector has economies of scale. To convey an idea of the concentration of the cod processing industry analyzed in this chapter, Table 2 displays the volume and percentage of cod sold to the five largest buyers in the ex-vessel market in 2010-2011 (there was a total of 55 buyers in the market).[2]

Table 3: Volume (tons) and percentage of Baltic cod sold to the five largest buyers in Sweden 2010-2011.

Processor	**Volume (tons)**	**Percentage of Total Harvest**	**Cumulative Percentage of Total Harvest**
1	5006	25.3	25.3
2	4084	20.6	45.9
3	2351	11.9	57.7
4	2193	11.1	68.8
5	2127	10.7	79.5

As evident from the table, the majority of cod landed is sold to five large buyers that purchased almost 80% of the total landings. In the extreme case when fishers can only deliver to a single processing firm, we would expect the processor to offer a low ex-vessel price close to fishers' average cost and thereby extract all the rents generated in the fishery. In fact, the data used in this study shows that it is not unusual for one buyer to dominate the purchases in many of the smaller ports.

It is also evident from the data that fishers are highly dependent on specific ports and buyers. From 1 April 2010 until 31 December 2011 244 vessels landed cod in 58 Swedish Baltic harbors. Table 3 presents some statistics that show this dependency.

[1] Although new vessels were allowed to enter in 2011 the number of passive vessels continued to decrease after the reform (from 181 before the reform to 173 after the reform). Thus, the relaxed entry regulation did not seem to affect competition among vessels.
[2] Buyers are assumed to be processors or deliver to processors. We make no particular distinction between them.

Table 4: Fisher dependency on buyers and ports.

Number of buyers (x)	Share of total number of vessels that sold their landings to x number of buyers	Number of ports (y) visited	Number of vessels that visited y number of ports over the time period
1	65%	1	61.50%
2	20%	2	25.40%
3	12%	3	9.40%
4	2%	4	2.90%
5	0%	5	0.40%
6	1%	6	0.00%
		7	0.40%

Most vessels limited their landings to one particular buyer (65 %) and one particular port (62%), indicating that there is a strong dependency between sellers and buyers. Only 20 % of the vessels turned to 2 different buyers during the time period and 12 % of the vessels turned to 3 different buyers. Turning to more than three different buyers is very unusual; only 3% of the vessels turned to more than three buyers during the time period. The same pattern is revealed looking at the number of ports visited by the vessels: 25 % of the vessels visited two ports, 9 % visited three ports and only 3.7 % of the vessels visited more than three ports during the time period. In addition, many vessels seem to be attached to one port, making only sporadic journeys to alternative ports.

As processors are highly dependent on a continuous supply of raw fish to make efficient use of their processing capacity and fulfill their commitments in the downstream market, they would like to prevent irregular landings. Irregular landings and seasonal closures force processors to import cod from abroad in order to guarantee a stable delivery of processed fish to food markets and other retailers (Swedish Board of Fisheries, 2010b; County Administrative Board of Skåne, 2005). The weekly catch rations were intended to mitigate this problem. In the new management system with annual individual quotas, fishers can afford to be more patient in waiting for more profitable fishing periods. In this situation, an individual processor may need to offer higher ex-vessel prices to ensure a continuous supply of fish. If there is competition among processors, this price-raising action may induce other processors to raise their prices in order not to lose future contracts in the downstream market. Thus, we expect the new management system to increase ex-vessel prices through the increased bargaining power of fishers, especially since the fishery is more or less closed to new entrants.

3.4 The bilateral bargaining model

Some researchers have considered fisheries as consisting of an oligopsonistic processing sector buying fish from oligopolistic fishers (see Matulich et al., 1995 and the references therein). As noted by Fell and Haynie (2011) and Matulich et al. (1995), most of the relevant aspects discussed above can be captured in the bilateral bargaining model suggested by Blair and Kaserman (1987) and Blair et al. (1989). In this framework, an upstream firm (oligopolist) sells its products to a downstream firm (oligopsonist) and the firms bargain over how to split the profit resulting from their joint activities.

The intermediate good price (in our case the ex-vessel price) reflects the bargaining outcome, and can be modeled as a linear combination of the price that would emerge from complete domination by the fisher and complete domination by the processor. We can illustrate the general idea by the following equation for the ex-vessel price:[3]

$$p = \alpha\left(p^d - p^u\right) + p^u, \tag{1}$$

where p^d is the downstream firm's (processor's) reservation price and p^u is the upstream firm's (fisher's) reservation price. That is, the fisher would prefer not to fish if he is offered a price below p^u. Similarly, a processor would not accept a price above p^d. For a transaction to occur, it is required that $p^d \geq p^u$. While the second part of (1) constitutes the lower bound of p, the first part is subject to negotiation between the fisher and processor. The coefficient α, which lies between 0 and 1, signifies the level of fishers' strength in determining the ex-vessel price. For example, if $\alpha = 0$, processors will capture all of the profits generated by the fishery as the ex-vessel price is equal to the fishers' reservation price (if there is no outside option for the fisher, the reservation price equals the average cost of catching a unit of fish). On the other hand, if a large number of processors compete for raw fish, we expect $\alpha > 0$ so that the price of cod is above p^u. The next section describes our approach to analyzing the effects of the new management system on the first part of (1).

3.5 Estimating the price effects of a change in bargaining power

Equation (1) above suggests that the bargaining power could be estimated given observations on p^d and p^u. However, the reservation prices are typically not observed. Moreover, α may not be constant over time. To overcome these difficulties, Fell and Haynie (2011) propose an unobserved-component model to decompose the observed ex-vessel price into its unobservable components (α, p^d, p^u). Estimation of the model is carried out by the use of nonlinear filtering techniques and requires the authors to specify the two functions determining the reservation prices, and a time series model for the bargaining coefficient. Although promising, a precise estimate of the bargaining power requires an adequate specification of the functions determining the reservation prices, and data on relevant explanatory variables. Failing this, we may obtain spurious estimates of the bargaining power coefficient.

In this paper we follow Fell and Haynie (2011) in that we allow the bargaining power to be time-varying. However, in contrast to them, we make use of a quasi-natural experiment to explore the changes over time. The idea is very simple: to measure the effect of the increased flexibility, we are interested in the price difference before and after the new management system, $p^a - p^b$. Here, p^a denotes the realized ex-vessel price if the fisher benefits from increased flexibility, and p^b is the ex post counterfactual outcome. If, on the other hand, the fisher is not affected by the regulatory change, p^b will be realized and p^a will be the ex post counterfactual. Of course, we cannot observe both p^a and p^b because a fisher cannot be in both states. Instead, we use ex-vessel prices for fishers observed in one of the two groups (fishers using active and passive gear) in one of the two time periods (before and after the new management system). That is, while we are primarily interested in the group of fishers who benefit from the new management system (fisher using active gear), the segment of passive gear is used as a control group and the bargaining power effects are

[3] This is basically the same formula as equation 4 in Blair and Kaserman (1987) and equation 2 in Fell and Haynie (2011).

operationalized as changes between the two groups. More specifically, let p_{tlsq} be the average cod price at date t, in landing port l, for a particular size, s, and quality, q. We calculate the price difference between the groups as, $\tilde{p}_i = \tilde{p}_{tlsq} = p^a_{tlsq} - p^b_{tlsq}$ where the superscripts a and b, indicate the group (active gear and passive gear, respectively) and $i = 1, \ldots, N$. We consider two time periods, $M \in \{0,1\}$, which correspond to the two management periods (before and after the regulatory change). The so-called difference-in-difference (DID) estimator is given by

$$\hat{\pi}_{DID} = (\overline{p_1} - \overline{p_0}), \tag{2}$$

where $\overline{p_m} = \sum_{(i|M=m)} \tilde{p}_i / N_m$ is the average price difference in management period m. By taking differences between groups we remove potential biases that could be a result of time trends (demand and supply fluctuations etc.) unrelated to the regulatory change. Similarly, the differencing over time removes any biases, which could be the result from permanent differences not related to the new management, in second period comparisons between the groups. To illustrate the benefit of the difference-in-difference approach, we use a slight modification of equation (1),

$$p = p^u + \epsilon, \quad where \quad 0 \leq \epsilon \leq p^d - p^u, \tag{3}$$

where ϵ reflects the markup over the fisher's reservation price. Combining equation (2) and (3) we obtain

$$\hat{\pi}_{DID} = \left((\overline{p^u_1} + \overline{\epsilon_1}) - (\overline{p^u_0} + \overline{\epsilon_0}) \right), \tag{4}$$

with obvious definitions of $\overline{p^u_1}, \overline{p^u_0}, \overline{\epsilon_1}$ and $\overline{\epsilon_0}$. Assume for the moment that there is no systematic difference in reservation prices between fishers using active and passive gear, or that the difference in reservation prices is constant over time. In this case, $E(\tilde{p}^u_i) = 0$, which implies that $E(\hat{\pi}_{DID}) = E(\overline{\epsilon_1} - \overline{\epsilon_0})$. In other words, using the DID approach we can test whether fishers gain a higher markup in the new management period, controlling for a variety of confounding factors such as the quality and size of fish, port-specific characteristics that change over time and aggregate time trends such as supply and demand fluctuations. In practice, of course, it is not known if the reservation prices vary systematically between the groups, making it difficult to attribute an increase in price differences to increased bargaining power. We elaborate on this issue below.

An estimate of $\hat{\pi}_{DID}$ can be obtained from the dummy variable regression

$$\tilde{p}_i = \beta + \pi_{DID} \cdot W_i + u_i, \tag{5}$$

where u_i is the error term and W_i is an indicator variable, taking the value 1 in the new management period (after 1 April 2011) and 0 otherwise. That is, we are primarily interested in the quantity $E(\tilde{p}_i | W_i = 1) - E(\tilde{p}_i | W_i = 0) = \pi_{DID}$. The overall intercept β, reflects the difference in price between the groups prior to the new management system.

3.6 Results

The results from regression (5), presented in Table 2, show that there are price differences between the two groups after the reform when controlling for size, quality, port and landing day. The interpretation of the coefficient is that vessels using active gear received 0.24 SEK more on average than vessels using passive gear during the time period following the reform, and that this price increase was unrelated to the size or the quality of the fish, or where and when it was landed. The constant shows the average price difference before the reform and since it is not significant it suggests that there were no price differences between segments prior to the reform when controls are used.

Table 5: Results – price differences before and after the reform

Coefficient	Point estimate	P-value
Constant (before)	0.027	0.454
Difference-in-difference coefficient (after)	0.239	0.000

Note: The number of observations is 1973.

Another way to envisage the difference between the two groups is to estimate the distribution of $\tilde{p}_i$. Figure 1 shows two density functions estimated using the Epanechnikov kernel density estimator.[4] The shaded area shows the estimated density of $\tilde{p}_i$ before the reform and the dashed line shows the estimated density after the reform.

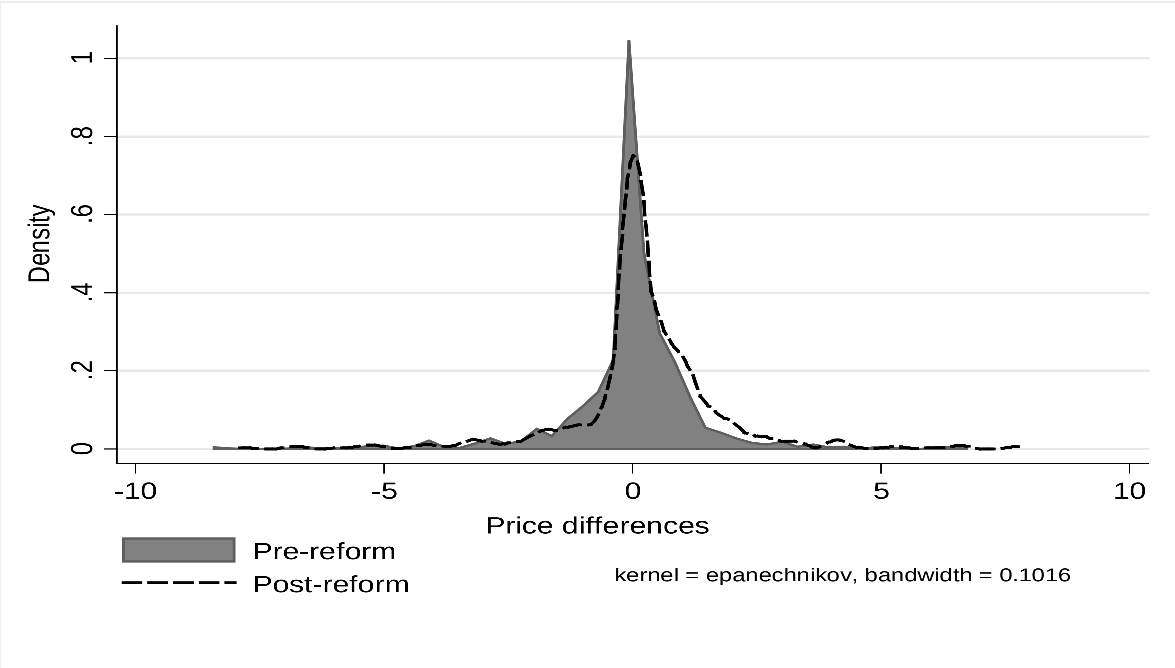

Figure 1: Kernel density estimates pre-form and post-reform

Figure 1 shows that the remaining price differences are slightly larger post-reform, and confirms the results of the regression. The post-reform density curve is to the right of the pre-reform density

[4] The bandwidth is estimated using the Silverman's (1992) optimal bandwidth estimator.

curve, indicating price differences are larger post-reform.[5] The pre-reform estimates are closer to zero, and most observations show no differences between vessels using passive gear and vessels using active gear when other factors (size, quality, landing-day and -port) are controlled for in the analysis. The figure also shows that there are no extreme observations driving the results.

While the results in Table 5 and Figure 1 indicate higher ex-vessel prices for fishers who profited from the new management system, they are not indicative of whether the price difference changed abruptly or gradually over the year. Nonparametric regression methods can be used to analyze the behavior of the conditional mean around a particular point in time. Let x be a time-variable representing date and consider $m(x) = E(\tilde{p}_i|x_i = x)$, where $m()$ is some unknown mean function. Instead of using equation (5), we want to estimate the conditional mean directly, without making any assumptions about the functional form of $m()$. In this case, we can use the Nadaraya-Watson estimator[6],

$$\widehat{m}(x) = \sum_{i=1}^{N} \tilde{p}_i \cdot \lambda_i, \tag{6}$$

where λ_i is a kernel weight function. As above, we use the Epanechnikov kernel. However, when it comes to bandwidth selection, there is no commonly used rule of thumb like the one used above. Instead, we experimented with several different choices for the bandwidth (30, 40, 50, 60, 70, and 80). Fortunately, the qualitative results were not sensitive to this choice, and Figure 2 presents the estimated mean function when the bandwidth is set to 50.

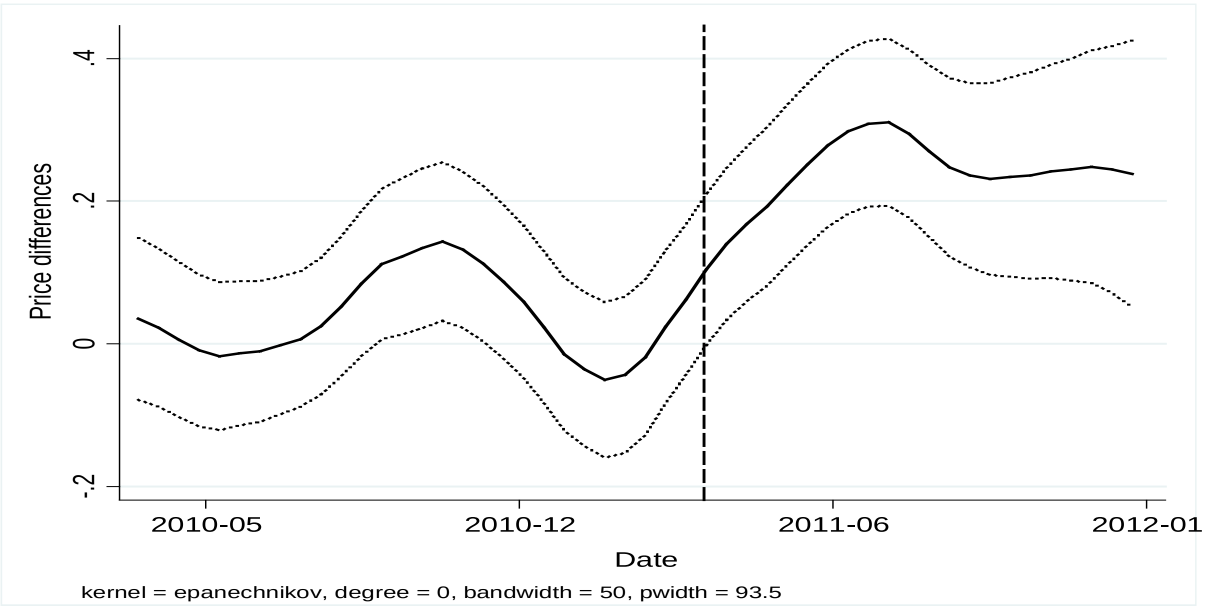

Figure 2. Estimated mean function of price differences

The estimated mean function shows that price differences vary somewhat before the reform, but are larger after the reform. The figure also shows that price differences become larger immediately after the reform, and that they stay at a higher level during the rest of the time period studied. The interpretation is that increased bargaining power of the fishers prevailed throughout the time period.

[5] The hypothesis that price differences are equal before and after the reform is tested using the Kolmogorov-Smirnov test. The hypothesis is rejected at the 1 percent level.
[6] See for example Racine (2008).

It is also evident from the figure that there were no other major changes in price differences after the reform. On 1 September 2011 trawl-fished cod from the Eastern Baltic became liable under the Marine Stewardship Council (MSC) labeling scheme. Such a scheme could potentially increase prices to fishers who incur costs when implementing the regulations of the scheme. However, the figure is in line with an estimation of regression (5) for the time period between 1 April 2011 and the end of that year with a break on 1 September 2011; this regression reveals no significant changes in price differences.[7]

As the Nadaraya-Watson estimator is a smoothing estimator, it may mask an abrupt shift in the conditional mean around the date of the new management system. To allow for a discontinuity point, Figure 3 displays the results from the Nadaraya-Watson estimator when the mean function is estimated separately for the two management periods.

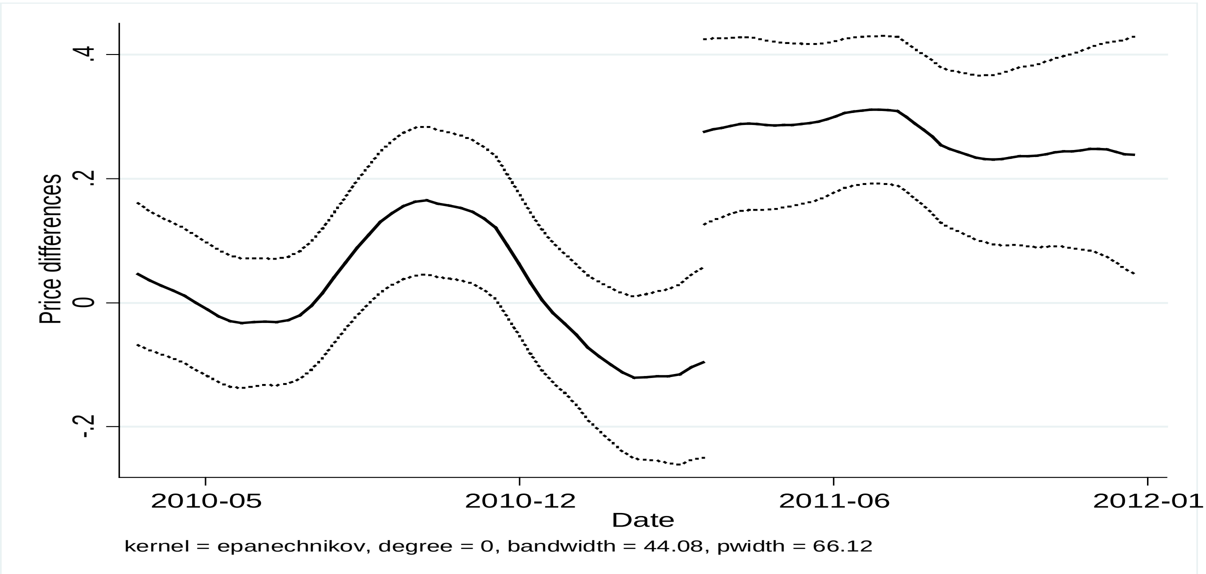

Figure 3. Estimated mean functions for two separated time periods

The figure shows that there is a clear break on the date when the reform was introduced, i.e. on 1 April 2011. Price differences before the reform are smaller than price differences after the reform. Just like Figure 3, it is clear that price differences remained throughout 2011.

The results above clearly suggest that the new management system results in higher ex-vessel prices for fishers using active gear. However, in terms of equation (1), the results are not indicative of whether the higher prices are due to improved bargaining power or a shift in fishers' or processors' reservation prices. For example, the processors' reservation price is likely to be a function of the average variable costs of processing. To investigate this issue, we follow Fell and Haynie (2011) and assume that processing costs are dependent upon the quantity processed. More specifically, we define the variable $\tilde{q}_i = q^a_{tlsq} - q^b_{tlsq}$, where q^a_{tlsq} and q^b_{tlsq} denote the average quantity landed at date t, in landing port l, for a particular size, s, and quality, q, where the superscripts a and b indicate group membership (active gear and passive gear, respectively). The variable $\tilde{q}_i$ can then be included as an explanatory variable in regression (5). If processor reservation prices for the two groups of vessels change disproportionally, this might affect price differences. Similarly, the fishers'

[7] The number of observations of this regression is 770.

reservation price is likely to be determined by their fishing costs. To control for fishing costs, we include the daily changes in diesel price, $d_t = d_i$. Usually, active vessels are more fuel intensive than passive vessels, and if diesel prices change, the reservation price of active vessels might change more than the reservation price of passive vessels. Table 3 shows the results when these variables are included in regression (5).

Table 6: Estimation results from equation (5) with diesel prices and differences in quantities included

Variable	Point estimate	P-value
Constant	-0.011	0.812
Difference-in-difference	0.233	0.000
Diesel price	-0.004	0.993
Difference in quantity	0.017	0.257

The results indicate that reservation prices for processors or fishers have not changed disproportionally between vessel groups. The coefficients of diesel prices and quantity changes are very small and insignificant. Thus, the price effect is more likely to be related to an increase in the bargaining power of fishers.

3.7 Summary and conclusions

In this chapter we contribute to the literature on how the distribution of rents between fishers and processors changes when a regulatory change is introduced in a fishery. More specifically, we focus on how the bargaining power of fishers is altered when we move from a system of quarterly to annual quotas in the Swedish Baltic cod fishery.

The results indicate that bargaining power increases for fishers, since price differences between vessels affected by the reform and vessels not affected by the reform are larger after the reform holding other factors fixed. On 1 April 2011 active vessels were no longer restricted by the quarterly quota that had been in effect during the previous year. Passive vessels had no quota restrictions during the investigated period. The price increase due to increased bargaining power is estimated to 0.24 SEK, which is equivalent to 1.8 percent of the pre-reform price received by vessels using active gear. The price increase appeared immediately after the reform and also remained during the months following the reform.

The justification for the empirical model is that fishers and buyers bargain over the price of fish. In our study we have a limited number of buyers since the market is dominated by five large agents. Vessels have close-knit relations with their buyers and are also closely connected to specific ports. Thus, a bargaining situation is likely to occur where the actual price ends up somewhere between the reservation prices of the buyers and the sellers.

Using a detailed dataset and a difference-in-difference approach, the study abstracts from other factors that could have affected the prices during the time period. Prices of fish of the same size, with the same quality rating, landed in the same ports, and on the same day are compared for the two segments. Thus, any price changes related to these factors are left out of the analysis. Furthermore, the difference-in-difference approach ensures that all factors which affected prices in a similar manner for the two segments during the time period are left out of the analysis. Such price changes could for example be changes in the demand for cod, macro-economic fluctuations or changes in input prices. Finally, we investigate whether the results are driven by changes in reservation prices. Assuming that processing costs are dependent on the quantities that are processed, we include differences in quantities in the two segments in the regression. Changes in fishers' reservation prices are estimated using diesel prices assuming that these prices reflect fishers' marginal costs. We do not find any support for the notion that differences in reservation prices changed over the time period and thus affected price differences. Thus, we cannot reject the hypothesis that the bargaining power between fishers and buyers has changed, and that the price effect which appeared immediately following the reform on 1 April 2011 was an effect of the increased bargaining power of fishers.

The discussion on making fishing quotas transferable is an on-going issue in Sweden as well as in the EU, and an introduction of transferable quotas in the Swedish Baltic cod fishery could be realistic in the future, at least for active vessels. The bargaining power of fishers could then raise ex-vessel prices further, since rationalization in the fishery sector could result in the exit of the most inefficient fishers and increased market power of the remaining fishers. The potential bargaining effects of an introduction of transferable quotas and the discussion about compensation to processors are interesting questions for the future. This paper suggests that the bargaining situation between fishers and buyers is affected by a regulatory change, and thus policy makers should consider market distortions when introducing new management systems.

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Swedish coastal herring fisheries in the wake of an ITQ system

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ABSTRACT

The European common fisheries policy (CFP) advocates measures to sustain small-scale fisheries; hence, in the European Commission's proposal for a reformed CFP, these are exempted from a mandatory system with tradable fishing concessions. This opens up for management actions designed for small-scale fisheries, but also implies new management issues. This article provides insights into the topic based on a Swedish small-scale herring fishery in the western Baltic Sea that was exempted from an ITQ-system. The fishery has been profitable since the system was introduced, and the increasing effort of both incumbent fishermen and new entrants implies a situation where fishermen compete for a limited quota. The migratory pattern of the herring implies high densities in the southern parts of the fishing areas during spring and in the northern parts during autumn. This forms the basis for two different fisheries in the area, as well as for the current management proposal to divide the quota into a spring and an autumn part. This and other management proposals are discussed in the paper. The main conclusion from the case study is that, when exempting a fishery from tradable fishing concessions, it is important to build other institutions dealing with the fundamental problem of access to the quota. Failure to do so might result in an over-capacity issue and threaten the long-run development of an otherwise successful small-scale fishery.

1. Introduction

The European common fisheries policy (CFP) advocates measures to sustain and promote small-scale coastal fisheries in order to enable them to prevail and thrive alongside larger-scale fisheries. This is highlighted in the EU commission's proposal for introducing a mandatory system with individual transferable fishing concessions [1]. The proposal is limited to vessels above 12 m and/or vessels using active gear, and the inclusion of smaller vessels is a national decision for each member state. A reason for not including them is to protect the small-scale fisheries from being bought out by larger vessels. However, exempting a small-scale fishery from a management system is fundamentally different from successfully managing it.

Exempting a fishery from a system with individual transferable quotas (ITQ) implies that part of the quota is set aside for the fishery. Theory predicts that with open access to the quota the system will generate a biologically sustainable fishery (as long as the quota is set according to biological recommendations) with low profitability. The latter because as long as the fishery is profitable it will attract new entrants, which in turn implies increased competition for the quota and decreased catch per vessel. New entrants will be in line with political employment objectives for small-scale fisheries, but if the quota is limited, the process might generate over-capacity.

Following the increasing number of ITQs and other systems with tradable fishing concessions, the development of biological [2,3], economic [4–6], and socioeconomic [7] values for these systems has become publicly available in the literature. The development of segments fishing on the same stocks but exempted from the system are less studied although commonly occurring.[1]

In this paper a Swedish small scale herring fishery in the western Baltic is used to show the development and management issues of a fishery that is excluded from a large scale ITQ system.

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[1] An exception is [8], who describes a system where Icelandic vessels could leave the ITQ system for an effort-based management option and then re-enter ITQs again. This led to increased fishing effort, at least partly motivated by the possibility of re-entering with an improved catch record.

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Sweden is part of the CFP, and Swedish political objectives regarding the small-scale fleet include employment opportunities, economic viability, rural development, etc. [9]. Profitability in general is low in the Swedish Baltic Sea small-scale fishery [10] and recruitment to the sector is low. With this in mind, a major objective of exempting the small-scale fishery from ITQs is to use the quota to attract new fishermen. However, the current issue in the herring fishery is that the fishery has expanded rapidly, leading to competition for the quota. Incumbent fishermen are part of the traditional fishery which was protected from being bought out by large scale fisheries through the ITQ-exemption, but they now face the risk of the quota being fished by others since they fish later in the season than new entrants.

Although coastal fisheries have high political priority and the studied herring fishery has a separate quota that can be managed with targeted measures, the Swedish fisheries authority has not yet presented a long-run sustainable management plan for the fishery. Situations like this, with national authorities being responsible for managing a small fishery, will emerge in the proposed reform of the CFP. Central management of a small-scale fishery is expensive in terms of the economic contribution of the fishery, and efficient management systems are necessary to deal with the topics. In this paper, proposed management options for the coastal Swedish herring fishery are presented and discussed from both a theoretical and a management perspective.

The paper continues with a presentation of the herring stock (“The biology of the western Baltic herring” section) and the Swedish ITQ system (“The Swedish pelagic ITQ system” section). In “The coastal fishery” section the coastal fishery and the problems arising due to the expansion are discussed. The “Management proposals” section contains the management options proposed for the fishery, and the “Discussion” section concludes the paper with a discussion.

2. The biology of the western Baltic herring

The herring stock in the western Baltic Sea and the Sound between Sweden and Denmark (Öresund, ICES subdivision 23) is mainly composed of a migrating and seasonally occurring population [11]. Although local (coastal) sub-populations are present in the area, the considerably larger Western Baltic Spring Spawners (WBSS) provide the main resource for the commercial herring fishery in the area. After spawning in the western Baltic Sea from March to May, the adult part of the population (i.e., age 2+) undertake a northward feeding migration, entering the Kattegat, Skagerrak and eastern North Sea through the narrow Belt Sea and the Sound [12]. Towards the end of summer the adults migrate southwards to the main overwintering areas in the southern part of the Kattegat and the western Baltic Sea [13], with peak aggregations (i.e., 45–165,000 t) in the Sound from September to February [14]. During overwintering, the highest densities are found primarily in the northern Sound, while high concentrations in the southern part are restricted to spring just before the onset of the spawning migration [14]. Given the high densities seasonally occurring within the narrow confinement of the Sound, conditions for a small-scale local gillnet fishery are particularly suitable, especially given the local trawl-fishing ban [15] limiting competition from large-scale trawlers in the area.

3. The Swedish pelagic ITQ system

Before the ITQ system was introduced in 2009, the Swedish pelagic fleet consisted of approximately 80 large-scale vessels fishing for herring, sprat, mackerel, blue whiting, and sand eel. The fishing takes place in the Baltic, Kattegat, Skagerrak, and North Sea. Excess capacity had been prevalent in the segment for years and the economic performance had been poor [16], and the idea of introducing an ITQ system was provided by the industry itself. Individual non-transferable quotas were introduced in 2007, and an ITQ system was put in place in autumn 2009 [17]. In 2011 the large-scale pelagic fishery consisted of 17 vessels. The system includes elements of both regional and small-scale considerations. An important feature in this is that part of the quota for each stock is set aside for small-scale fisheries using passive gear, the so-called coastal quota. Fishermen using the coastal quota cannot be part of the ITQ system.

4. The coastal fishery

The development of the total Swedish and the coastal quota is presented in Table 1. Initially the coastal herring fishery was small, but expanded rapidly and the coastal catches exceed the allocated quota in 2009 and 2010. The idea of the coastal quota is to enable the coastal fishery to continue “without limitations” [18], and extra allocations have been made. However, additional allocations are made at the expense of quotas for the ITQ-system, and in practical policies there will be an upper limit of the coastal catches.

A first observation is that the total Swedish quota has declined continuously since 2008 (due to a general reduction of Total Allowable Catch agreed in the EU) from almost 8000 to 2800 t. The western Baltic herring quota is a small part of the total ITQ system, but is important for coastal fisheries. The coastal quota has increased from 400 t in 2008 to 565 in 2011 with a maximum of 800 t in 2010. The development of the coastal quota is due to a larger share of the total quota allocated to coastal fisheries each year.

In total about 40 Swedish fishermen have their primary fishing area in the Öresund where the western Baltic herring is caught. The main targeted species are Atlantic cod (Gadus morhua), Atlantic herring (*Clupea harengus*) and European eel (*Anguilla anguilla*). In 2011 approximately 20 fishermen were active in the herring fishery, although some of them only had marginal catches. The herring fishery in the Öresund has been profitable in recent years, but, at the same time, the important cod fishery has declined. This may explain the increase in the coastal catch presented in Table 1. The increase is due not only to existing fishermen increasing their herring fisheries, but also to newcomers discovering the herring in the Sound. Increasing fishing pressure has previously been solved by increasing the coastal quota, but this is not an option in the long run.

Further, fishing in the Öresund has a North-South dimension, where the fishermen in the northern part of the Sound are largely ‘traditional’ fishermen focusing on autumn when the price for herring is high and the herring is overwintering in high densities in the North. The fishery in the southern part of the Sound has been described as ‘bulk fisheries’ focusing on larger quantities in the spring when the herring is gathering in the southern parts of

Table 1
Swedish herring quotas in ICES area 22–24 (Western Baltic Sea), ton
Source: The Swedish agency for marine and water management.

Year	Swedish quota	Coastal quota	Coastal catch	Coastal quota, (%)
2008	7926	400	284	5.05
2009	4835	400	817	8.27
2010	4037	800	952	19.82
2011	2826	565	554	19.99

the Sound. The prices are in general lower in this fishery. In 2011 the average price was SEK 4 in January and SEK 5.4 in September (€1 ≈ SEK 9), i.e., an increase of about 35%. At present the fishery is characterized by open access for vessels using passive gear as long as the total coastal quota is not exceeded. The problem, as described by the regional fisheries management, is that the coastal quota will not last for the entire year and the autumn fishery in the North will face a quota deficit if additional quota allocations cannot be made. The seasonal pattern of the landings in the northern and southern parts of the Öresund is presented in Fig. 1 (Swedish landings in both Swedish and Danish harbors).

5. Management proposals

The regional fisheries management has brought the problems facing the local herring fishermen in the Öresund to the attention of both the fishery and the central authority (the Swedish Agency for Marine and Water Management). Three ideas have been informally discussed, but only the third has been formally proposed as a management solution.

The first idea for solving the situation was to form a co-management organization where the fishery is closed for new entrants. In this approach, the quota will be allocated to the fishery and the fishermen can solve the quota issues internally. The approach has been rejected since the very idea of the coastal quota is to allow new entrants into herring fisheries.

The second idea is to introduce rationing where each fisherman is to be allowed a fixed catch per week (or other limited time period). This is a traditional Swedish management option that has been used on a large scale for both cod and herring fisheries. It is still used for small-scale fishing for mackerel. However, several drawbacks have been put forward: It is not possible for the fishermen to allocate their fishing activities to the optimal time period when prices are high or herring fishing for other reasons is profitable for the company. Further, a rationing system will be expensive to administer since authorities will have to keep continuous track of the weekly catches for each vessel.

The third idea is to divide the quota to a spring and an autumn part (formally the division is into four periods). This has been proposed by the fishermen themselves, but the proposal is problematic due to different ideas among fishermen regarding the size of the spring and autumn shares. Separate spring and autumn quotas are still the main options, and the county administrative board has made a formal proposal to the Swedish Agency for Marine and Water Management to split the quota.

6. Discussion

The management system for the Swedish coastal herring may be described as regulated open access under a catch quota. A fishery that is characterized by ’race to fish’ will lead to excess capacity and low profitability, and large vessels fishing early in the season are expected to get a higher share of the quota. The Swedish coastal herring fishery might be viewed as a micro-example of this situation. New entrants and ‘bulk’ fisheries in the southern part of the Sound fishing a large share of the quota during the spring causes problems for the fishermen active in the autumn when prices are high. As long as the fishery is profitable and one of the main purposes of the coastal quota is to allow the entry of new fishermen, competition for quotas is expected to be an important characteristic of the fishery.

It could be argued that the quota should be fished in the autumn when prices are high, but this is only one dimension of the situation. The high coastal quota is due to the new entrants and the larger fisheries in the South, and the quota would probably not be utilized if only caught in the autumn. Further, the fishermen in the South are heavily dependent on the spring fishing due to the bad cod catches in recent years. The idea of the coastal quota is to allow new fishermen to establish themselves, and if entering the herring fishery is a way for these small-scale fishermen to stay in business, it has served its purpose. The problem is whether it is at the expense of others.

When a fishery is put under pressure, it is important to have strong institutions to deal with the problem, and this is not the case in the situation presented above. The individual quotas work as such an institution in the ITQ-part of the herring fishery, but other institutions are politically preferred in the coastal fishery. The co-management alternative for the coastal quota was rejected due to possibilities of generous access to the fishery, but is still interesting to mention as a possible solution in the future. The fishermen constitute a small homogeneous group that is dependent on the resource, and has the common goal of utilizing the stock for commercial purposes. These are important characteristics for the possible success of a co-management body [19]. Under the right conditions, local management of a small fishery might be a cost-effective strategy with strong support among fishermen. The current strategy of dividing the quota to a spring and an autumn part might solve the problem in the short run, but has obvious drawbacks as a long-run solution since it does not deal with the fundamental issue of access to the quota: New entrants might still join the fishery, thereby reducing catch possibilities per vessel, and there are no legal sanctions against fishermen conducting spring fishing and then choosing to participate in the autumn fishing as well.

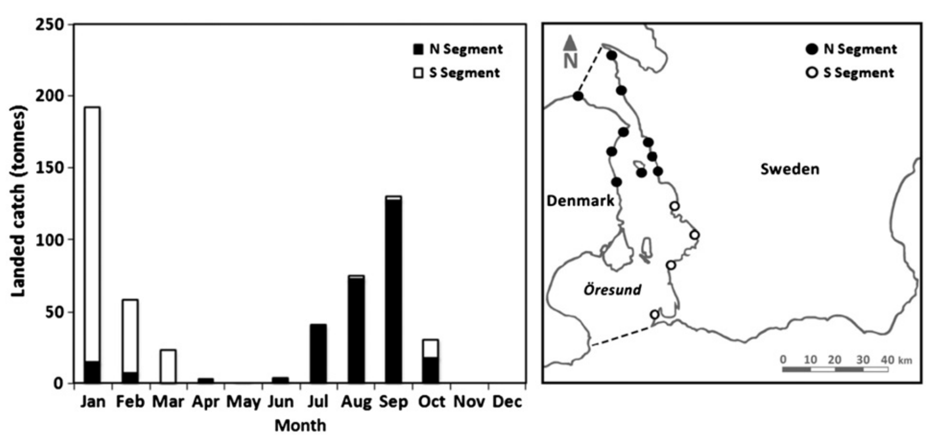

Fig. 1. Swedish landings of Atlantic herring (*Clupea harengus*) in the Öresund, 2011.
Source: the Swedish agency for marine and water management.

Taking the lessons learned from the Swedish example into the framework of the CFP reform, the exemption of the small-scale fishery from the system with tradable fishing concessions did not solve the problems facing the small-scale fleet. If a fishery becomes profitable, it will attract new capacity and there is need for a management system to solve the same over-capacity issues as have been present in the EU for decades, but on a micro-scale. It is important to have an institutional setting and a management plan to deal with the topics arising in these fisheries. The topics are not fundamentally different from those in larger scale fisheries. However, managing a small fishery might be expensive in terms of the economic gains from the fishery. Still, this cost might be motivated, since, in many cases, the reason for the fleet being exempted from tradable concessions is to protect values other than the strictly economic.

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