

Ex-vessel Price of Cod in Iceland Empirical and Contract-Theoretical Consideration

Thorolfur Matthiasson

Dept. of Economics, University of Iceland

Benedikt Valsson:

Managing Director

Federation of Officers of Icelandic Fishing Vessels and Merchant Ships

Abstract: Ex-vessel price formation of fish in Iceland has been a stumbling stone within the fisheries for a long period of time. Fish as a raw material for processing has been sold either in direct sales or through auction markets leading to different prices. In many cases direct sales leads to considerably lower prices than the outcome on the auction markets. In this context it is attempted in this paper to cast some light on this issue by analysing the development of the price systems applied in the industry. Furthermore, we apply theoretical methods of contract theory to gain understanding of how the share system and contracts between owners of vessels and owners of on-shore facilities might influence the development of ex-vessel price of fish in Iceland. It is also discussed what problem of measurement one has to tackle with when conducting empirical investigation of data regarding price of fish.

Key words: Price formation, direct sales, auction markets, the law of one price, share system, contract theory.

1. INTRODUCTION

Stigler (1985) ask if the New York Commodity Exchange and the Chicago Board of Trade constitute two separate or one single market for silver future contracts. They also examine the degree of integration of the wholesale markets for wheat in Minneapolis and Kansas City and the wholesale markets for gasoline in New Orleans, Chicago and Detroit. Gordon and Hannesson (1996) similarly ask (but use more sophisticated econometric methods) if the North America and Europe constitute single or separate markets for fresh and frozen cod. Gordon, Salvanes et al. (1993) test the linkages between fresh cod, fresh turbot and fresh salmon on the Rungis Fish Market in Paris, France. The studies here mentioned examine linkages between markets that are separated geographically or by the biological and/or physical characteristics of the product. In Iceland fresh fish is sold on auctions and in direct sales. The buyers and sellers on both markets are non-distinguishable from geographical point of view. The product sold in one market could just as well have been sold in the other market. Hence, economic theory and experience from other markets suggest close linkages between the price of fresh cod, say, at the auction market and in direct sales. This is not the case. The level of prices and the variation in prices on the two markets are different. One is tempted to ask if fundamental insights like the Law of One Price do not apply for the market for fresh fish in Iceland. The purpose of this paper is to offer an explanation of this phenomenon that is consistent with economic theory and the observed facts.

Formation of ex-vessel price of fish in Iceland has not been studied much. In a paper Arnarson (1998)

asks how the introduction of auction markets for fresh fish in the 1990s has affected small-scale fishers and internal migration in Iceland. Based on interviews they conclude that the introduction of auction markets has raised the price of fresh fish and made it easier for independent small-scale processors to enter the processing sector. A number of authors have contributed on the matter of ex-vessel price formation of shrimp in the US. See Doll (1972) and Houston (1989) and the references cited therein. Lin, Richards et al. (1987) studies the ex-vessel price formation for Pacific Halibut while Matulich, Mittelhammer et al. (1995) studies ex-vessel price formation for Alaska King Crab. The purpose of most of the authors is to explain year-to-year price variations. Houston et al. is the only study comparing prices in different locations.

2. HISTORICAL BACKGROUND

During the last 50 years ex-vessel price formation of fish in Iceland has been subject of significant changes. The ex-vessel price of fish was and is a parameter of importance for buyers and sellers of fresh fish. The ex-vessel price of fish in Iceland has also been and still is an important macro-economic parameter.

Consider first the period before 1960:¹ An indicative-ex-vessel price of demersal species (of which cod was and is the most important specie) was bargained between the association of fishing firms and the association of processing firms. Hence, individual fishing vessels owners and their crews had to settle on ex-vessel price to use during the season or part of season as the

¹ The historical overview is based on: Halldórsson (1999), Sigurdsson (1978) and Oskarsson (1991).

fishermen's remuneration was based on sharing the imputed value of the catch based on this indicative ex-vessel fish price. To complicate matters further fish products produced from catch of trawlers commanded an exchange rate of the krona that was different from the exchange rate commanded by products produced from catch of smaller vessels! The price paid in krónur for one kilogram of a given fish-specie to smaller vessels (bátar-boats) was sometimes as much as 45% higher than price of one kilogram of the same fish-specie to trawlers. The ex-vessel price of pelagic species, of which herring was the most important, was determined by a governmental institution, The Herring Committee (Sildarútvegsnefnd). The Herring Committee had monopoly on selling herring in the important market in Eastern Europe and the Soviet Union, complementing the monopoly that the state owned firm, Sildarverksmiðjur Ríkisins (SR), had on the reduction process. (Independent producers were free to enter salting of herring. Hence the state did not have total monopoly of processing herring). To sum up: Trawlers commanded lower price for their catch than small vessels and that price difference was supported by a complicated system of multiple exchange rate for the currency.

By the end of the 1950s the price-formation institutions for fresh fish were criticised as source of misallocation of economic resource and as a cause of growing discontent among fishers. In 1961 a labour dispute within in the fisheries resulted in a wide spread fishermen's strike that lasted for two months. A part of the solution to this dispute was the abolition of the multiple-price system for fresh fish and the establishment of The Official Icelandic Fish Price Board (Verdlagsráð sjávarútvegsins, established by an Act of Law from the parliament late in 1961). The role of the Official Fish Price Board was to announce minimum price for all commercially caught species intended for processing in Iceland. In the beginning the Official Fish Price Board was obliged to base its decisions on the developments of export prices for fish products. That guiding principle was augmented in 1964 to include also consideration regarding the cost of production in the fishing and the processing sectors. The Official Fish Price Board had 12 members, 6 members represented the sellers (vessels owners and fishermen) and 6 represented the buyers (processors). In the cases where the Official Fish Price Board did not reach an unanimous decision the decision was left to a special committee (icel. Yfirnefnd – e. Supreme Fish Price Board). The Supreme Committee had five members, two representing the sellers, two representing the buyers and a fifth member, the Chairman, appointed by the Minister of Fisheries. The Chairman was usually the director of the National Economic Institute. A simple majority in the Supreme Committee was needed to decide the minimum price of fish. In some cases a decision was made by the one vote of the Chairman.

The system within the framework of the Official Fish Price Board lasted for nearly three decades. During that period the system had a profound impact on the economy as a whole. When the prices decided by the Price Board led to an operational deficit within the fish processing industry, then the processing industry was compensated with increased income in krónur by devaluation of the currency. This process of increased fish prices and devaluation of the currency was one of the sources that maintained a high rate of inflation in Iceland during the 1970s and the 1980s.²

Legislation governing work at the Official Fish Price Board was changed once again in 1991. The Supreme Price Board was discarded. Furthermore, it was decided that simple majority was a sufficient basis for an effective decision of minimum prices of fresh fish. The most important reason for this change was that auctions markets for fish had been established few years earlier (in 1987 to be exact). Having prices formed by supply and demand gained popularity. (In 1998 the proportion of fresh cod sold at auction was up to 30%). A second reason for the 1991 changes of the legislation governing the work of the Official Fish Price Board was that the decisions made by the board were becoming more out of line with the actual prices paid for the catch in direct sales between fishing vessels and fish processing plants. A third reason was more widespread integration of fishing vessels firms and processing firms. It proved hard to decide if an integrated firm was to be categorised as a processor or as a fishing firm. Hence, it was hard to decide who should represent such a firm at the Official Fish Price Board.

The Official Fish Price Board has mostly been inactive since 1991. Fishermen's expectations were that all fresh fish would eventually be sold on auction

² The goal of the Official Fish Price Board towards the end of the period in question was to fix fish prices in a manner that ensured that the income of fishers developed along the same lines as income of workers in other industries. The goal of the Central Bank was to keep the value of the currency such that economic resources were fully employed. Assume that wages of wage earners in construction, transport etc are raised by 10%. Then the Official Fish Price Board would increase the price of fish by 10%. Processors would now have increased costs and income fixed in dollars. Many of them would face the difficult decision to reduce their operation or even close it down. That was a situation that the Central Bank and the government wanted to avoid. The solution would be to devalue the króna by 5%. That devaluation would cause the internal inflation to jump, undermining the real wage of the wage earners, inducing discontent and labour disputes setting the stage for a new round of wage increases, fish price increases and devaluation!

markets.³ These expectations have only partly been fulfilled. Most of the catch is sold directly to processing plants. Hence, the price formation of fish for on-shore processing has been in the form of bargaining between the crews of individual vessels and the owner of an integrated fishing company.

The dispute of ex-vessel price of fish in direct sales between fishers and fishing firms has been characterised by frequent labour disputes and even strikes during the last 10 years. In 1994 there was a national fisher's strike that lasted two weeks. In the end the government banned the strike by Provisory Act of Law.⁴ The fishermen's unions' main demand during that strike was that all fresh fish should be sold on auction markets. Furthermore, the fishers demanded that the praxis of charging crew members for a substantial part of the cost of leasing extra quota for a vessel should be banned. The Provisory Act (Confirmed by the Parliament during its next regular session) established a Price Dispute Court. The purpose of the Price Dispute Court was to solve disputes between vessel owners and crews if other forms of dispute resolution did not work. The establishment of the Price Dispute Court was not a successful solution to the problem at hand, as is evident by the fact that in 1995 fishers did strike again, this time for 3 weeks. The fishers' demands were the same as before: a) All fresh fish should be sold at auction markets and b) fishers should not participate in cost of leasing quotas. The dispute in 1995 was brought to conclusion with an agreement between the Fishermen's Unions and the Fishing Vessel's Owners Organisation. The agreement prescribed that the Price Dispute Court should be replaced by a new institution, The Price Settlement Committee. One of the members of the new institution is appointed by the Minister of Fisheries. That appointee has to be chosen among the judges at the lower level courts in Iceland. The Price Settlement Committee has extended power as compared to the Price Dispute Court. The new institution can fix a price of catch to be used when crew share is calculated. The Committee can prescribe that the price it

³In the collective agreement between the Fishermen's Union and the Fishing Vessel's Owners Organisation there is a clause requiring that: "the vessel's owner should provide the crew with the highest possible price for their share of the catch". Hence, fishers expected that the introduction of auctions markets would bring price formation of fresh fish more into the open. That in turn, they hoped would tempt some vessel owners to sell their catch to publicly known (high) price making it harder for integrated firms to use artificially low prices when calculating the crew share on their vessels.

⁴ According to the Icelandic Constitution the government can authorise a Provisory Act of Law if the Parliament (Alþingi) is not in session. A Provisory Act must be confirmed by Alþingi during the next regular session if it is to remain active.

fixes remains valid for as long as 3 months in each individual case. The rules regarding the Price Settlement Committee were embodied into a new Act of Law by Alþingi in 1995.

The existence and rulings of the Price Settlement Committee did not succeed in reducing the discontent among fishers. Crews were still dissatisfied with the price that their share of catch was said to command when the catch was sold in direct sales. Crews did find it problematic to send a formal complaint to the Price Settlement Committee. Furthermore, the problem of crews' participation had not been tackled. Fishers proclaimed that crews were increasingly forced to pay part of the rent for extra quota for vessels that were running short of their own allotment. Such participation in paying for rented quota was (and still is) prohibited by the collective agreement and by law. The form of the payment was usually to lower the price per kilogram of catch by the amount paid for renting the right to catch that kilogram. Crews faced with the decision of either accepting lower price for their share or finding a new job often choose the lower pay. The Price Settlement Committee was not equipped with instruments to deal with the problem of quota rent participation.

Fishers did strike once again in 1998. That was the third fishers strike in the 1990s. The demands were the same as before. Once again the government ended the strike by an Act of Law. The rules governing the working of the Price Settlement Committee were changed. The committee could prescribe compensation to crewmembers for the rest of the season if a vessel owner did not comply with previous rulings of the committee. Hence, a vessel owner that did take his vessel out of operation could be forced to pay his crew as if the vessel had been in normal operation until the end of the quota year. Furthermore, the Act prescribed the institution of the Fresh-fish Price Directorate (Verlagsstofa skiptaveris). The Directorate is to collect, in a systematic and comprehensive way, information on fish prices. The Directorate is also to monitor contracts and prices and to reveal to fishers the "right" ex-vessel price of fish. The Act of Law also included the introduction of the Quota Exchange Market. Quota holders that would rent out their quotas and would-be quota lessees must make their deals through the Quota Exchange Market. The outspoken purpose of this institution was to make it harder for lessees to involve crews in costs of leasing quotas.

At the time of writing (June 2000) the dispute between vessel owners and fishers regarding ex-vessel fish price in direct sales in Iceland remains unsolved. It is not unlikely that new Acts of Law will be written and passed, that existing institutions will be given more powerful instruments and that new institutions with ambitious goals will be erected.

3. EX-VESSEL PRICE OF GUTTED COD IN ICELAND, 1998-1999

Fresh fish in Iceland is partly sold at auction markets in Iceland or in Western Europe, mainly in England or Germany. Fresh fish is also bought and sold directly. Some direct sales are inside an integrated firm. Other direct sales are between parties that are unrelated in terms of ownership. Icelandic fishermen are remunerated by share of revenue. Hence, the lower the ex-vessel price the lower is the pay of the crew, cet. par. Rigging a low ex-vessel price would enhance the profitability of an integrated firm. Rigging a low ex-vessel price could also be an option for unrelated fishing firm and processor if the processor agreed to divert funds back to the fishing firm disguised as payment for goods or services different from fresh fish. Hence, there are obvious gains to be made for vessel owners who manage to rig a low ex-vessel price of fish. Crews that suspect that prices are rigged can ask the Fresh-Fish Price Directorate to investigate the case. If the Fresh-Fish Price Directorate concludes that the evidence supports the suspicion of the crew it sends the case to Price Settlement Committee. If, after re-examining the evidence, the Price Settlement Committee finds that prices have been rigged the Committee can require that crew shares be recomputed. The Fresh-Fish Price Directorate collects information on fish prices on auction markets and in direct sales and disseminates the data on the World Wide Web. The aim is to ease the tension between vessel owners and crews and to help the Price Settlement Committee to conclude if prices are rigged at to low a level in direct sales.

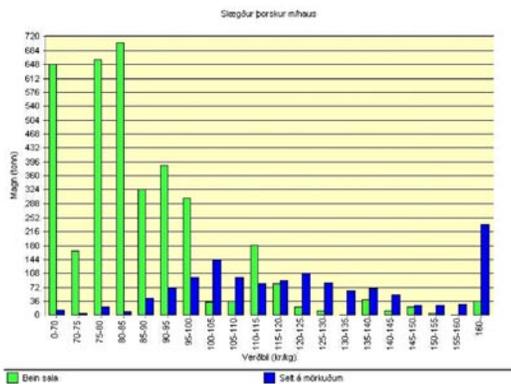


Figure 3-1 Price of whole gutted cod in August 1999. “Bein sala”=Direct sale, “Selt á mörkudum”=Auction market prices. Price in krónur per kilogram on the horizontal axis and quantity on the vertical axis.

Figure 3-1 shows the distribution of prices of whole gutted cod in August 1999 in Iceland. It is clear from the figure that most of the catch is sold directly from vessel to processor. Figure 3-2 shows the development of the average price of whole gutted cod for a 12-month

period. The price of cod at the auction market is significantly higher than price in direct sales during all the months that we look at. On average the price on the auction markets are 50% higher than prices in direct sales.

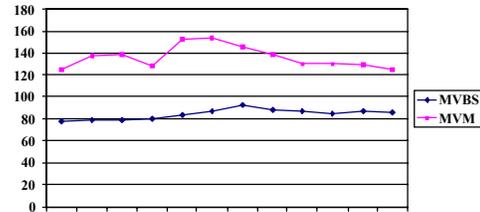


Figure 3-2 Average price of whole gutted cod, September 1998 to August 1999. MVBS=Average price in direct sales, MVM=average auction market price.

Figure 3-2 indicates that the price difference between markets and direct sales narrows during the summer months (the quota year starts at September 1st). Figures 3-3 and 3-4 illustrate the evolution of the coefficient of variation and the coefficient of skewness through the year.

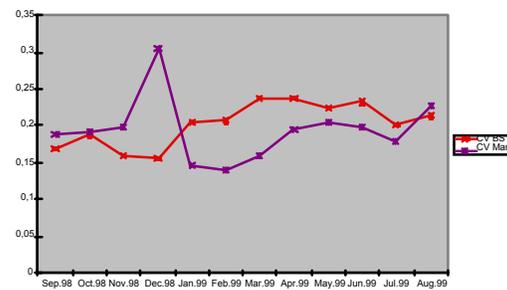


Figure 3-3: Coefficient of Variation for price of whole gutted cod in Iceland, September 1998 to August 1999. CVBS is coefficient of variation for price in direct sales; CVMark is coefficient of variation for price at auction markets.

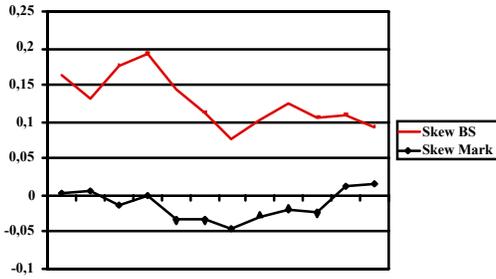


Figure 3-4 Coefficient of Skewness, for prices of whole gutted cod in Iceland, September 1998 to August 1999. Skew BS is coefficient of skewness for direct sales; Skew Mark is coefficient of skewness for auction markets.

The coefficients show that the distribution of prices at auction markets is almost symmetric around the mean and the distribution of prices in direct sales is positively skewed. Work is under way to establish if this pattern is consistent over a longer period and in more disaggregated data (we are looking at data for types of gear and location of point of sale).

The data clearly indicate that the development of prices at the auction market and prices in direct sales are directed by different principles. This is a bit puzzling when the results reported in the papers cited in the introduction are taken into account. Just as a rose is a rose, then whole gutted cod is whole gutted cod and one would expect whole gutted cod to demand the almost same price in direct sales as when sold on auction markets.

4. THE ICELANDIC MARKET AND THE EXTERNAL MARKET FOR FRESH FISH

Assume that the price of fresh fish in a foreign market is p^* krónur per kilo. Furthermore, assume that the cost of freight of a kilo of fresh fish to/and from the foreign market to and from Iceland is f krónur. Denote the qualitative loss during freight from Iceland to Europe as $100v_{IE}\%$ of the value of the catch. Furthermore, denote the loss in quality when fish is hauled to Iceland from a foreign market as v_{EI} . Normally, in the absence of governmental interventions and in the absence of unexpected news with respect to domestic supply and domestic and foreign demand⁵, one would expect the following inequality to hold

⁵ News that affect supply of fish in any given week is weather at the fishing spots, announcements regarding the probable or actual TAC for next fishing season, labour disputes in the fisheries or the transport sector etc. News that affects demand for fish domestically or in foreign markets concern health related matters. Television

$$(1 - v_{IE})p^* - f \leq p^M \leq (1 - v_{EI})p^* + f \quad (1)$$

Here p^M is the market price in Iceland. Assume now that the reduction in quality due to freight is the same when fish is transported to Iceland, as it is when fish is transported the other way around. Hence,

$$v_{IE} = v_{EI} = v \quad (2)$$

The assumption in equation (2) may seem innocent but one must keep in mind that in the late 1990s much of the fish transported to Iceland was transported by Russian trawlers while fresh fish transported the other way around was transported either on Icelandic trawlers or in specially designed containers. There are indications that suggest that the reduction in value of fish transported by Russian trawlers was larger than reduction in value of fish transported by other methods. This difference may be of importance in practice even if ignored in the present set up.

Taking (2) into account the inequality contained in (1) can be simplified in the following manner:

$$(1 - v)p^* - f \leq p^M \leq (1 - v)p^* + f \quad (3)$$

Subtracting $(1 - v)p^*$ from each side of the inequality (3) and simplifying yields,

$$|p^M - p^*(1 - v)| \leq f \quad (4)$$

The entity $p^*(1 - v)$ can be interpreted as being the quality adjusted price of a kilo of fish caught in Icelandic waters and brought to the foreign market when taking the effect of transport on the quality of the fish into account.

Inequality (4) implies that the difference between the price gained in the domestic market per kilogram of fish and the quality adjusted price of that kilogram in the foreign market can normally not be bigger in numerical value than the cost of transporting fish between the domestic market and the foreign market. Hence, equations (3) and (4) define a band inside which the internal market price can move. A higher v or a higher f will broaden the band and lower values of these variables will narrow it. The proposition implied by the two

programs on problematic parasites in cod and redfish have had dramatic negative effect on consumer demand in Germany. Concerns about sanitary conditions in production of beef have had positive effects. This list can of course be made much longer.

equations is well known.⁶ It should be noted, however that the weight loss parameter ν implies that the difference between the price of a kilo of fish in Iceland can be permanently higher or lower than the price of a kilo of fish on the European market even when transport costs are taken into account.

It is worth noting that the wedge between the prices on the Icelandic ex-vessel market and the prices on the European (or foreign) market should tend to narrow as more effective techniques for transporting fish are introduced. Increased efficiency in the transport of fish should reduce ν as well as f . The development of the container market can be viewed as the result of a simultaneous reduction in ν and f . Use of containers allowed more effective control of temperature of the fresh product during haul from Iceland to Europe and reduced cost of shipping each kilogram.

Governmental measures

The formulas (1) to (4) are developed under the assumption that government does not interfere in the ex-vessel market for fish. That is not a valid assumption in the case of Iceland. Catch of the economically important species in Icelandic waters is governed by an ITQ system. According to the regulation governing the ITQ system a kilo of catch sold to an Icelandic processor and a kilo exported fresh do count differently against the quota of the seller. Taking that fact into account implies that inequality (4) can be written in the following manner:

$$(1 - \nu)(1 - s)p^* - f \leq p^M \leq (1 - \nu)p^* + f \quad (5)$$

Here s reflects the implicit quota tax imposed on the sellers of fresh fish to the external market. Note that if $s=0$ then the two relationships (4) and (5) are identical. The introduction of the implicit quota tax widens the possible difference between the domestic and the foreign market price of fresh fish. Hence, the higher the implicit quota tax the lower is the domestic market price that triggers independent vessel owners to offer their catch at the foreign market. Furthermore, it may be inferred that an increase in the implicit quota tax will increase the overall supply of fish for domestic processors. But as the increase in supply coincides with low domestic market price an increased implicit quota tax may actually direct the raw fish into low value added uses.

⁶ See McClausky in Politics and Society, Volume 18, Issue 2. See also Stigler (1985) who remind us that relations like inequality (4) will usually hold for most of the time. If the inequality is not fulfilled the forces of supply and demand will restore it. Whether the forces of supply and demand need minutes, days, weeks or years to restore the inequality depends on the situation in the given market.

5. THE INDEPENDENT VESSEL OWNER

Consider an independent vessel owner that hires his crew and sells the catch at the internal fish market. The crew is hired on basis of a gross revenue share, α , and a “guaranteed” minimum income, \bar{Y} .⁷ The problem of the independent vessel owner can be formulated in the following way:

$$\begin{aligned} \text{Max}_{x^M} \Pi(x^M; \alpha, p^M) &= (1 - \alpha)p^M x^M - c(x^M) \\ \text{s.t. } \alpha p^M x^M &\geq \bar{Y} \end{aligned}$$

The vessel owner solves the problem by bringing catch, x^M , to shore so that the following conditions are met:

$$(1 - \alpha)p^M = \frac{\partial c(x^M)}{\partial x^M} \quad \text{for } x^M \geq \frac{\bar{Y}}{\alpha p^M} \quad (6)$$

$$\text{and } \Pi(x^M; \alpha, p^M) \geq 0$$

The vessel owner will plan to catch $x^M = \frac{\bar{Y}}{\alpha p^M}$ even if condition (6) is not met as long as

$$\Pi\left(\frac{\bar{Y}}{\alpha p^M}; \alpha, p^M\right) \geq 0.$$

It is easily shown that the fishing plan given by (6) yields inefficient use of resources in the Marshallian sense, as the ex-vessel price of catch, p^M , is larger than the marginal cost, $c'(x^M) = \frac{\partial c(x^M)}{\partial x^M}$. The reason for this result is that the vessel owner foots the bill of extending the operation so as to bring one more kilogram of catch ashore while he will only reap part of the revenue resulting from that action. This is a well know result from

⁷ The wage contract between vessel owners and fisherman’s unions determines a (low) guaranteed income. Hence, if actual catch and/or price of catch is very low the fishers are paid “secured-pay” (kauptrygging). The guaranteed minimum income alluded to in the text is not the “secured-pay” of the union agreement. The guaranteed minimum income is the lowest expected income that an able fisher finds acceptable. Hence, the guaranteed income will be influenced by income in other lines of activities open to fishers, by the general level of income in the economy. Hazards to health and life and excessive work effort will also influence the size of the guaranteed minimum income.

the sharecropping literature. See Quibria (1984) for more details and a survey.

6. INDIVIDUAL VESSEL OWNER AND THE INDIVIDUAL PROCESSOR, THE BARGAINING PROBLEM

Processors that enjoy stable flow of freshly caught fish to their plants are likely to enjoy higher profitability than processors that must live with erratic supply, *cet. par.*, as both must hire labour and capital beforehand irrespective of how effectively those factors of production are utilised. Hence, a lower than expected supply of fresh fish implies waste of resources already amassed. A processor has basically two ways of reducing the uncertainty with respect to supply of fresh fish. One method is to integrate harvesting and processing.⁸ Another method is to secure flow of fresh fish by contracting supply of fish with independent vessel owners. The problem of the integrated firm will be analysed in the next section, while the problem of bargaining a contract between an independent processor and an independent vessel owner will be discussed below.

Note that there is no organised market where processors can post offers for vessel owners or vessel owners can post offers to processors. Hence, a processor and a vessel owner have to bargain over the contract on a bilateral basis. The contract is usually effective for one season at a time.

A vessel owner that takes his catch to the auction market can secure profit given by $\Pi(x^M; \alpha, p^M)$. The processor whose capacity is small relative to the overall capacity in the industry will behave as if he can secure all the fresh fish he will need at the market price, p^M . Hence, the lowest profit the processor foresees is given as $\Gamma(z, 0; q, p^M) = qf(z) - p^M z$. Here z is the quantity of fish for processing, $f(z)$ describes the production process utilised to transform fresh fish into some other saleable product (frozen, salted, dried, consumption ready, etc.), q is the price of the processed product. The second argument of the $\Gamma(\cdot)$ function is a parameter (γ) that describes the degree to which the processor reimburses the vessel owners for his cost of operating the vessel. When the processor buys at the market this parameter is set equal to zero, but can be in the range

⁸ An integrated firm can face the problem of temporary oversupply of fresh fish. The integrated firm can in such a situation, choose to sell part of the catch at an auction market, or it can choose to process the fresh fish with less input-demanding processes.

between 0 and 1 if the processor and the vessel owner have a bilateral contract.

The vessel owner and the processor are assumed to behave as if maximising the Nash product taking into account the threshold below which crew income can not fall. Furthermore, the bargaining parties have to observe that the capacity of the vessel is limited. Given those restrictions the bargaining can be simulated as solving the following program:

$$\begin{aligned} & \underset{p^B, \gamma, z}{Max} \left[(1 - \alpha) p^B z - (1 - \gamma) c(z) - \Pi(x^M; \alpha, p^M) \right] \\ & \bullet \left[qf(z) - p^B z - \gamma c(z) - \Gamma(z, 0; q, p^M) \right]^{\delta} \\ & = \underset{p^B, \gamma, z}{Max} \left[\Pi(z; \alpha, p^B) - \Pi(x^M; \alpha, p^M) \right] \\ & \bullet \left[\Gamma(z, \gamma; q, p^B) - \Gamma(z, 0; q, p^M) \right]^{\delta} \end{aligned}$$

subject to:

$$\alpha p^B z \geq \bar{Y} \quad \text{and} \quad z \leq \bar{z}$$

Here γ is a parameter given the share of costs that the processor reimburses the vessel owner. The parameter δ reflects the bargaining strength of the vessel owner. Now, associate the Lagrange multiplier λ with the first constraint listed above and associate the Lagrange multiplier μ with the second constraint. Then the solution must satisfy the following conditions.

$$\begin{aligned} & \frac{\delta(1 - \alpha)}{\left[\Pi(z; \alpha, p^B) - \Pi(x^M; \alpha, p^M) \right]} \\ & \frac{(1 - \delta)}{\left[\Gamma(z, \gamma; q, p^B) - \Gamma(z, 0; q, p^M) \right]} + \lambda \alpha \leq 0 \end{aligned} \quad (7)$$

$$\text{or } p^B = 0$$

$$\begin{aligned} & \frac{\delta}{\left[\Pi(z; \alpha, p^B) - \Pi(x^M; \alpha, p^M) \right]} \\ & \frac{(1 - \delta)}{\left[\Gamma(z, \gamma; q, p^B) - \Gamma(z, 0; q, p^M) \right]} \leq 0 \end{aligned} \quad (8)$$

$$\text{or } \gamma = 0$$

$$\frac{\delta[(1-\alpha)p^B - (1-\gamma)c'(z)]}{[\Pi(z;\alpha,p^B) - \Pi(x^M;\alpha,p^M)]} - \frac{(1-\delta)[p^B + \gamma c'(z) - p^M]}{[\Gamma(z,\gamma;q,p^B) - \Gamma(z,0;q,p^M)]} + \lambda\alpha p^B - \mu \leq 0 \quad 9)$$

or $z = 0$

The complementary slackness conditions yield:

$$\lambda(\alpha p^B z - \bar{Y}) = 0 \quad \text{and} \quad \mu(z - \bar{z}) = 0. \quad (10)$$

We can now state two propositions regarding the contract between the vessel owner and the processor.

Proposition 1: If $\gamma > 0$ and $z < \bar{z}$ then the contracted volume of catch is determined in such a way that the marginal cost of operating the vessel [$c'(z)$] equals the ex-vessel market price of catch, p^M .

Proof: As $\gamma > 0$ equation (8) yields that $\frac{\delta}{[\Pi(z;\alpha,p^B) - \Pi(x^M;\alpha,p^M)]} = \frac{(1-\delta)}{[\Gamma(z,\gamma;q,p^B) - \Gamma(z,0;q,p^M)]}$. Inserted in (7) observing that a meaningful contract implies that $p^B > 0$ so that $-\lambda = \frac{\delta}{[\Pi(z;\alpha,p^B) - \Pi(x^M;\alpha,p^M)]}$. Together with 9) this $= \frac{(1-\delta)}{[\Gamma(z,\gamma;q,p^B) - \Gamma(z,0;q,p^M)]}$ implies that $p^M = c'(z)$. QED

Proposition 1 implies that the contract between the vessel owner and the processor is efficient in that no improvement in the size of the operation can be worked out that is mutually beneficial for the contracting parties. Assume that the cost function for the vessel owners has the usual properties. Then the planned operation of the contract vessel is larger in terms of planned catch than the size of operation of the same vessel would have been if catch were to be sold at the auction market. Before the reason for this result is discussed it is useful to introduce the next proposition.

Proposition 2: If $\gamma > 0$ and $z < \bar{z}$ then ex-vessel price of fish will be sat according to the formula $p^B = \frac{\bar{Y}}{\alpha z}$ where z is the catch given by proposition 1.

Proof: Given that $\gamma > 0$ and equations (7) and (8) we have that $\lambda \neq 0$. Hence, for the complementary slackness condition given by equation (10) we have that $p^B = \frac{\bar{Y}}{\alpha z}$. QED.

The implication of the two propositions is that the vessel owner and the processor fix the two parameters, p^B and γ in such a way that the crew gets remunerated according to the participation constraint. Furthermore, the surplus from the overall contract is distributed to the two contracting parties according to their bargaining strength.

Corollary 1: If $\gamma > 0$ and $z < \bar{z}$ then ex-vessel price of fish caught by a vessel with a delivery contract with a processor of the type described above will not be influenced by the market price of fresh fish.

Proof: Follows directly from proposition 2.

Before the discussion is taken further we will consider the contracts that an integrated firm offers fishers.

7. THE INTEGRATED FIRM

The integrated firm combines the operations of a processor and a vessel-operating firm. The objective-function of the integrated firm can be written in the following manner:

$$\Lambda(y^p, y, p^l; \alpha, p^M, q) = qg(y^p) - p^M(y^p - y) - c(y) - \alpha p^l y$$

s.t. $\alpha p^l y \geq \bar{Y}$ and $y \leq \bar{y}$

Here p^l is the ex-vessel price of fish that the firm stipulates, y^p is the quantity of fresh fish that is processed by the integrated firm. The variable y indicates the quantity of fish that the vessel of the integrated firm brings ashore. If $(y^p - y) > 0$ then the integrated firm had to buy fish at the auction market. If on the other hand $(y^p - y) < 0$, then the integrated firm has sold part of the catch of its vessel at the auction market. The function, $g()$, is a production function with the usual properties (positive first derivative, negative second derivative, etc.) Now, associate the Lagrange-multiplier λ^l with the first constraint and the Lagrang-multiplier μ^l with the second constraint.

The necessary conditions for maximum are given as:

$$qg'(y^p) - p^M \leq 0 \quad \text{or} \quad y^p = 0 \quad (11)$$

$$c'(y) - \alpha p^l + p^M + \lambda^l \alpha p^l - \mu^l \leq 0 \quad \text{or} \quad y = 0 \quad (12)$$

$$-\alpha y + \lambda^l \alpha y \leq 0 \quad \text{or} \quad p^l = 0 \quad (13)$$

The complementary slackness conditions yield:

$$\lambda^I(\alpha p^I y - \bar{Y}) = 0 \text{ and } \mu^I(y - \bar{y}) = 0 \quad (14)$$

We are now able to state:

Proposition 3: If $y \leq \bar{y}$, then the integrated firm will set $p^I = \frac{\bar{y}}{\alpha y}$.

Proof: Assume that $p^I > \frac{\bar{y}}{\alpha y}$. From (13) we have that a positive ex-vessel price implies $\lambda^I = 1$. But we assumed that $p^I > \frac{\bar{y}}{\alpha y}$. Given that assumption the complementary slackness condition requires that $\lambda^I = 0$. Hence, assuming that $p^I > \frac{\bar{y}}{\alpha y}$ yields a contradiction. QED.

Corollary 2: The ex-vessel price of fish will not be influenced by movements in the auction-market price of fish when the precondition of Proposition 3 is met.

Proof: Obvious.

The following picture should help to understand the formation of price:

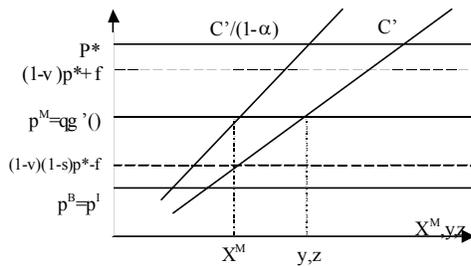


Figure 7-1: Formation of ex-vessel price of fish. $C'/(1-\alpha)$ indicates how cost varies with size of operation as viewed by an independent vessel owner. C' indicates how cost varies with size of operation of a vessel as viewed by a vessel owner that has a contract with a processor or as viewed by an integrated firm.

Figure 7-1 describes how an individual vessel owner will behave given the assumption that all vessel owners possess the same cost function. An independent vessel owner that does not have a contract with a processor will dimension his operation in such a way that the production will be x^M . He will sell all his production at the going market price, that also is the value marginal product of the processing firms. A vessel owner that has a contract with a processor or an integrated firm will dimension their production such that they will catch y or z tons of fish. When they pay wage to their crews they will stipulate a price equal to p^I or p^B . The figure is drawn to show how the same product (fresh fish) can be quoted with different

prices at the same moment. The foreign market price can be considerably higher than the internal market price, which in turn can be considerably higher than the price that an integrated firm will stipulate when doing the wage calculation for its share crews.

We can therefore conclude that the theoretical model discussed above offers an explanation of the odd behaviour of the ex-vessel price of fish on auction markets and in direct sales in Iceland.

8. BARGAINING OVER THE CREW SHARE

In the introduction we did mention that fishers have gone to strike 3 times during the last 10 years. The unresolved dispute regards the ex-vessel price of catch when the vessel operation and the on-shore activity is integrated or when the owner of a vessel and a processor have a delivery-price contract. Fishermen's unions have publicly voiced their concern that when vessel owners and processors fix the price of fresh fish that they buy in direct sales then they have huge incentive to keep this price at its lowest possible level and by that reduce the wage bill of the vessel owner.

The theoretical model indicate that a rational vessel owner and rational processors will negotiate a fish price that is low and use some other method than pricing of the fish to transfer funds from the processor to the vessel owner. The theoretical model also indicates that one side effect of the negotiating process is that vessel owners are likely to expand the operation of their vessels in a way that is economically efficient. Hence, vessel owners have a point when they say that the contracts they make with processors enhances overall efficiency in the economy as compared with a situation where all fish is brought to auction markets and revenue is shared between vessel owners and crews according to an eternally fixed share parameter. Thus, we can conclude that the system of direct sales satisfies certain criteria for economic efficiency in the Marshallian sense. But is it the only arrangement that has these positive characteristics? The answer is no. Other arrangements can give the same results with respect to economic efficiency without leaving the fishermen out of the bargain.

Note that the Marshallian inefficiency result alluded to above is derived based on an assumption of fixed share ratio. The Icelandic fishery sector is highly dynamic. Hence, one can question the assumption of fixed share ratio. New or enhanced gear, new or enhanced equipment offers the opportunity to renegotiate the size of the share ratio and the size of the crew.⁹ How

⁹ The share ratio stipulated in the collective wage-agreement between vessel owners and fishermen's unions is rather complicated. It stipulates both the overall share ratio and the number of men for given size of vessel utilising a given gear fishing for a given species of fish. The agreement allows that number of men in a crew is

would such constantly renegotiated share parameters affect efficiency?

The Nash product can be written as:

$$N = [(1 - \alpha)p^M b - c(b)] [\alpha p^M b - \bar{Y}]^\varepsilon$$

Here b is the quantity of fish that the crew and the vessel owner agree that should be brought ashore, \bar{Y} is the minimum income that the crew is willing to accept. The parameter ε reflects the bargaining strength of the vessel owner. Note that the minimum income is here defined by the crew and not by vessel owners as in bargaining problems that we have analysed above. Hence, the minimum in the present problem represents what the current crew is willing to accept while the vessel owner would rather have in mind the minimum income of any able crew. Consequently, one would expect $\bar{Y} \geq \bar{Y}$. The share ratio is a choose variable in this problem.¹⁰ The necessary conditions for solving the bargaining problem can be written as:

$$p^M = c'(b) \quad (15)$$

and

$$\frac{\varepsilon}{[(1 - \alpha)p^M b - c(b)]} = \frac{1 - \varepsilon}{[\alpha p^M b - \bar{Y}]} \quad (16)$$

Equation (15) implies that use of productive resources is efficient. Thus, it is not necessary to leave the crews out of the equation in order to secure efficient production. Note that the price p^M used in the negotiations must be expected market price as the negotiating parties must reach an agreement on the size of the share parameter before the start of the season.

Together the two equations (15) and (16) yield:

$$\alpha = 1 - \varepsilon + \frac{\varepsilon \bar{Y} - (1 - \varepsilon)c(b)}{p^M b} \quad (17)$$

Multiplying both sides of equation (17) by $p^M b$ reveals that crew income will be a weighted average of the minimum income and vessel-operation value-added [$p^M b - c(b)$]. Hence, crew income will be correlated to the expected market price. Furthermore, crew income will be

reduced. In such a case, part of the share of the “missing” crewman is distributed among the rest. We have not tried to model complications of this kind.

¹⁰ When new technique is introduced the share parameters are re-aligned. An example of this was when processor-trawlers were introduced.

higher than the minimum \bar{Y} as long as the vessel-operation value-added is higher than the minimum income \bar{Y} .

We can therefore conclude that a system where ex-vessel price of fish is fixed at the auction market, and where crew shares are constantly renegotiated will be efficient in the Marshallian sense and will shift more of the fishery generated income to fishers.

9. CONCLUSIONS

Ex-vessel price of fish in Iceland has been and still is a matter of governmental concern. The ex-vessel price of fish was stipulated by a quasi-governmental institution, The Official Fish Price Board for almost 30 years, from the early 1960s until the very early 1990s. The Official Fish Price Board has not announced official prices for the most important species since 1991. Fresh fish is either sold at auctions or in direct sales. The price agreed in direct sales has been the matter of serious disputes between crews and vessel owners. In the present paper we have shown that there is a significant difference between prices at the auction market and prices in direct sales. The paper offers a contract model that explains the observed difference with reference to the fact that crews do not have a voice at the table when the terms of the transaction between a vessel owner and a processor are fixed. Our model is of course not the only model capable of explaining the observed difference between auction market prices and direct sales prices. But we believe that elements emphasised in our model are very important. We even dare to predict that an acceptable and stable solution to the re-occurring labour disputes in the fishery sector is preconditioned by a good solution to the ex-vessel price formation problem.

We hope to have demonstrated in the present paper that much is to be gained by deeper understanding of how ex-vessel price formation and crew remuneration influence the overall efficiency of the fishing industry. It is our belief that this is a field ready for fruitful research.

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