Fixed wage or share: Contingent contract renewal and skipper motivation

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Abstract:

Fishermen around the world are usually remunerated by shares. Iceland is no exception in that respect. The fixed wage systems,that have been tried out, have been short-lived and their utilization limited. The fundamental question asked in this paper is: Why do almost all vessel owners use the same remuneration principles? The answer offered is that the circumstances under which fishing is conducted play a vital role here. Surveillance of the conduct of employees is almost impossible. Hence, vessel owners must develop some system for motivating workers and to discourage shirking. It is shown that sharing is better than alternative forms of remuneration in that respect. The production unit is a small platform that is not easily abandoned during a trip. The product ofr a given trip is well- defined. All of these factors help to explain the prevalence of sharing in fisheries.

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1 Introduction

Fishermen around the world are usually remunerated by shares. The Icelandic remuneration system in fisheries is no exception in this respect. Remuneration in Icelandic fisheries takes the form of sharing of catch revenue, plus a guaranteed minimum income for the fishermen in case of a failed season. Other remuneration rules, including rules with a large fixed wage component, have also been tried out in Icelandic fisheries in connection with changes in technique, for instance when motors and engines replaced sails or oars.[1] Such fixed wage systems have been short-lived and their utilization limited.

Remuneration systems in industries other than fishing show more variety, as varied combinations of fixed wage systems, together with piece rate work, bonuses, and revenue- or profit-sharing systems, are often in use by different firms in the same line of activity, using similar production processes and selling similar products.

The puzzling question is: Why do almost all vessel owners use the same remuneration principles? Why are the vessel owners that remunerate their crews with fixed wages so very few? Why have the attempts to use other remuneration methods in Icelandic fisheries never lasted very long? Oneanswer to these questions could be that sharing of some form is superior in terms of motivating skippers to work hard. But it is now well-established in the extensive efficiency wage literature that firms can motivate workers to work hard under a fixed wage regime by paying relatively high fixed wages on the condition that low performers are fired. Obviously, such arrangements have not been found to be useful to the same extent in fisheries as in other industries. But it is not immediately evident just why fisheries differ from other industries with respect to remuneration regimes.

In this paper I develop a model illustrating how a profit-maximizing vessel owner tailors a remuneration package for skippers, keeping in mind that skippers can choose another line of occupation if prospective income in fisheries is not competitive. The vessel owner can choose between an efficiency-wage type fixed-wage system and a revenue-sharing system, or

[1] See Matthiasson (1996b).

some combination of these two. Irrespective of which of the three remuneration systems are in use, any skipper who performs poorly will be sacked. An important restriction introduced in the model is that lump-sum transfers can only go from the vessel owner to the skipper and not the other way around.

The paper is organized as follows: The next section gives a partial review of the economic literature on the motivational effects of remuneration systems and literature dealing specifically with the choice between efficiency-wage-based remuneration systems and share-wage-based systems. The third section contains a theoretical model developed with the particular features of the fishery sector in mind. The fourth section provides a further explanation of the conclusions of the model and some comparative static results. The fifth section concludes the discussion.

2 Motivational effects of remuneration systems

Economists have a long tradition of investigating the effects of remuneration systems on motivation. Some notable contributions have been made by: Libenstein (1957), who is concerned with the connection between a worker's performance and his well being; Stiglitz (1974), who explains sharecropping as an institution to share risks and provide incentives in situations where the monitoring of worker input is costly; and Moene (1981) and Lazear (1986), who examine the workings of piece rate remuneration systems. Following up on the work of Solow (1979) the idea of efficiency wages, which was introduced in Libenstein's (1957) paper, has become more and more popular.

In a world of zero transaction costs and fully informed agents a fixed wage system would perform as well as other systems of remuneration. The contracting agents would agree beforehand on the levels of effort, the size of the remuneration, and the sanctions allowed if any breach of contract occurred. The buyer of effort could determine, at no extra cost, whether the contract was kept by the seller. The seller would know that breach of contract would not go unsanctioned. Hence, the best move by the seller of effort would be to fulfil the requirements of the contract.[2]

Matters become more complicated when the level of effort supplied by the seller is not observable by the buyer of effort, as is the case in agriculture or fisheries. Production in agriculture and fisheries hinges on non-observable inputs in addition to labour effort. Suppose, cet. par., that a seller of effort would actually be worse off when supplying high levels of effort than low levels . In such a case a supplier of non-observable effort, working under the conditions of a fixed wage contract, would enhance his own welfare by collecting the wage according to the contract but supplying a lower-than-contracted-for level of effort. Take fisheries as an example: In the event that an absentee vessel owner were to complain about the amount of output produced by a skipper and his crew, the skipper, whether he was actually at fault or not, could claim that the weather had hindered production, or that the fish was not catchable at the fishing spot at the time that the vessel was out there, etc.

Knowing that supply of effort cannot be monitored, what kind of contract should a potential buyer of effort propose? "Contracting-out" (engaging an outside subcontractor) is one solution. In such a case the buyer of effort would link the payment to some measure of the product produced, without regard to the effort supplied. This form of contracting is widely used in the construction industry, in transportation services, in catering, in renovation work, etc. However, at least two problems may cause this solution to be unattractive to a potential seller of effort: In the first place, all risk is shifted to the subcontractor, putting a risk-averse agent in an uneasy position, and, in the second place, the product and/or some of the inputs supplied by the principal or the agent may not be well- defined or may not be objectively measurable.

[2]Lazear (1986, p. 417) offers a formal statement of the incentive-enhancing irrelevance of form of payment when inputs and output are observed perfectly.

Product definition in fisheries is usually easy enough to accomplish.[3] The problem in fisheries is more complicated on the input side. The vessel owner supplies knowledge related to the working of capital markets and in dealing with regulatory bodies on shore. In subcontracting, skippers assume the role of principals while vessel owners assume the role of agents. Hence, a contracted skipper may find himself in need of controlling the quality of the enterpreneurial effort supplied by the vessel owner.[4] Consequently, unless modifications are added to deal with these potential defects, this potentially profitable exchange will likely not be carried out if potential subcontractors are sufficiently risk-averse or if they suspect they may encounter disagreement over the size of the product produced or the inputs supplied at the end of the day.

Stiglitz (1974) shows how a share contract may solve the principal-agent problem, when the product is observable and the agents are risk-averse. The share contract reduces the risk borne by the subcontractor (the agent, “the share-cropper”), but links outcome withremuneration to compensate a hard-working “share-cropper”. Bowls and Ginits (1990) offer another solution that works whether the product is objectively measurable or not; this is based on contingent contract renewal. Suppose that a contract is “signed” for one period at a time. Contracts are either renewed or terminated at the end of each period. A seller of effort who has had his contract terminated cannot hide that information from other possible buyers of

[3]There is scope for quarrel over value of the catch when catch is delivered to a processing unit owned by the vessel owner. The Fishermen Unions in Iceland and Norway have gained political support so that parliaments have passed acts that guarantee minimum prices for fresh fish. The Fishery Price Board in Iceland is no longer effective, while the Fishery Price Board in Norway is still (1996) announcing effective minimum prices for fresh fish.

[4]A contracted skipper might, for instance, ask whether a vessel owner put enough effort into obtaining harvesting rights from the fishery authorities to fish with particular equipment in specific waters during a particular period.

effort. Hence, the seller of effort will know that any further relationship with buyers of effort is contingent upon his/her supply of effort at the present time.[5]

If the product or the supply of effort is unmeasurable or difficult to measure accurately, a buyer of effort may occasionally terminate a contract even if the seller has honestly kept his part of the contract. Would-be sellers of effort will gain knowledge of the contract-termination record of a buyer of effort. A buyer of effort who is overly eager to terminate contracts may find it hard to obtain a contract with new would-be sellers of effort at the beginning of the next period. Suppose, for a moment, that the supply of effort is observable without cost so that an honest supplier of effort is never fired and a "lazy" supplier of effort is always detected. Then the mechanism of Bowls and Ginits may be viewed as a repeated game where the players play a tit-for-tat strategy: The buyer of effort supplies the wage as long as the seller of effort supplies the effort agreed-upon , the seller of effort supplies the agreed-upon effort as long as the buyer supplies the wage. A deviating seller of effort would find himself unemployed in the next period. A deviating buyer of effort would not find any skippers in the following period.

It may be concluded that, even when supply of effort is hard to monitor and measure, buyers of effort can choose between several remuneration methods that in one way or another motivate workers to expand the supply effort above the minimum. In the model developed in the next section of the paper a skipper who brings in little catch during a season will be sacked. The vessel owner can make it worthwhile for the skipper to avoid being sacked by paying him a wage that is above market average, either in the form of a fixed salary, or in the form of a share of the revenue produced, or some combination. of the two.

Lazear (1986) develops a model for analyzing the choice between salaries and piece rates. Lazear points out that if workers have different skills, high performers will self-select

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[5]The idea that a landlord (a principal) can use repeated renewal of contracts to induce a tenant (an agent) to make efficient decisions can, according to Newbery (1975) be traced back to Johnson (1950). According to Newbery, Johnson observed that the predictions of a "classical" sharecropping model, regarding overuse of landlord supplied inputs, were not supported by facts. Johnson suggested several solutions, but the one he favoured was that the landlord "..grant only a short term lease, which makes possible a periodic review of the performance of the tenant". Newbery (1975, p. 113).

into firms with piece rates, while low performers will self-select into fixed wage firms. In an early paper, Moene (1981), develops a model where workers collectively decide on effort and the piece rate is decided either unilaterally by the firm or bilaterally in collective bargaining between the firm and a union. If trust between workers and the firm is low, a non-cooperative solution is reached, resulting in lower levels of effort and lower levels of profits and worker utility than could be reached in a cooperative setting. Eswaran and Kotwal (1985) develop a model where two unmarketable inputs, the ability to supervise labour, on the one hand, and managerial ability or ability to interpreted market information, on the other hand, are placed in the handsof landless workers/tenants and landowners. Landowners can either hire workers at fixed wage, rent land according to a fixed-rent contract, or offer a share contract. Their model predicts that a fixed-rent contract will emerge if would-be tenants are almost as effective at managerial tasks as landowners, regardless of the landowners' supervisory ability. Fixed-wage contracts will emerge when landlords are almost as effective as workers at supervision, while workers are much less able on the managerial side than are landowners. Lastly, share cropping surfaces when landowners are less effective than tenants at supervision and when tenants are less able than landowners at managerial assignments.

Kruse (1993) notes that firms sometimes use an "... above-market "efficiency wage"" to motivate workers when monitoring is costly. He then points out that such schemes could sometimes be replaced or supplemented by a profit-sharing arrangement. A profit-sharing scheme establishes a link between the performance of the employee and the remuneration that he receives. The performance-remuneration link is weakened by the fact that the employee may have to share the results of increased effort with all the other employees of the firm. This is generally referred to as the one-over-N problem, as the gain of an individual worker from expanding his own effort varies inversely with the number of workers participating in the profit-sharing scheme. In an one-shot game the result is likely to be low performance/low income for all workers. The situation might be reversed, Kruse points out, in a repeated game setting, where anyone not performing in accordance with a high performance/high pay strategy could be detected and punished.

Levine (1987), Levine (1989) and Moene (1990) compare efficiency wages and profit sharing in economy-wide models. Fitzroy and Kraft (1986) present a model where output depends on the observable effort supplied by individual workers, as well as on each worker's unobservable supply of cooperative activity. Workers are assumed to derive utility from income. Cooperation is assumed to yield both intrinsic benefits to each worker (depending on average cooperation in the workplace) as well as disutility that is an increasing function of individual supply of cooperation. Increased supply of observable effort is assumed to reduce worker utility. Fitzroy and Kraft investigate the results when workers are remunerated by a wage system using the observable effort as the only determinant of pay. They show that their model contains two symmetrical Nash equilibria, one where all workers supply a positive amount of cooperation and another where workers do not supply any cooperation. They also show that the "bad" equilibrium will be eliminated under an alternative remuneration system, where workers are paid an (infinitesimally) small share of profits. Furthermore, they show that their assumptions are supported by data from medium-sized metalworking firms in Germany.

Kraft (1991) provides an empirical comparison of four different incentive systems: Piece rates, profit sharing, contingent renewal (which he calls dismissals) and above-going-rate wages. The last two systems can be considered as alternative implementations of an efficiency wage. Kraft finds that use of profit sharing reduces dismissals. He also finds that profit sharing and dismissals have a positive effect on productivity, while the effect of piece rates and high wages is negligible on productivity.

Finally, Weitzman and Kruse (1990) give an overview of the theoretical literature discussing the pros and cons of profit sharing. Furthermore, they survey statistical and econometic studies focusing on the relationship between productivity and profit sharing. They find support for the thesis that profit sharing enhances productivity in a significant way.[6]

[6]In addition to the literature reviewed above there is now a growing literature on the optimal franchise contract. Based on the idea of "double moral hazard", Bhattacharyya and Lafontaine (1995) suggest a revenue sharing rule for such contracts. Bai and Tao (1996) suggest that franchised units produce two goods, one that results in local revenue, and another that enhances sales at other units. The collective good, "goodwill", will be undersupplied

In most industries, no one remuneration system seems to outperform all other remuneration systems. Consequently, we see the co-existence of two or more systems in many industries and we also see firms experimenting with various remuneration systems. Fisheries seems to be the exception to the rule that no one remuneration system has a clear edge ower others. In fisheries profit sharing or revenue sharing totally dominates today, as it has traditionally. This domination seems to be independent of how developed the "surrounding" economy is. One of the aims of the present paper is to compare, vessel-owner profits resulting from the choice of contract. The question asked is: When is a risk-neutral vessel owner better off remunerating his skipper by a fixed-wage contract with contingent renewal, and when is a share contract (with contingent renewal) more favorable?

3 The Model

Two agents, a vessel owner and a skipper, are for each single period of time, jointly engaged in a productive task (fishing). The engagement may or may not be continued in the subsequent period. The agents have to negotiate a contract providing for the remuneration of an unmeasurable skipper input, i.e. labour.[7] Labour can be supplied at different levels of effort. If the skipper supplies labour at a low level of effort the probability is lower that resulting catch will reach a given level, for any admissible level of catch, than if his supply of effort is high.[8] The vessel owner supplies capital (under capital we include the vessel, gear,

unless the "Head Office" makes it attractive to produce that good. Hence, Bai and Tao show that offering some units a revenue-sharing contract and other units a fixed-wage-direct-instructions contract may solve the profit maximizing problem of the head office.

[7]More precisely the vessel owner is partly renting the skippers human capital consisting of knowledge of fishing spots, knowledge of organizing work on a fishing vessel, knowledge of operating a vessel in rough waters, knowledge of putting the gear to profitable use without destroying it, etc.. The vessel owner is partly renting the immediate supply of manual labour necessary for conducting a fishing trip.

[8]More precisely: Denote high level of effort as H and low level of effort as L and assume that effort can not be supplied in other quantities. Then the statement in the text says that: $Prob(X \leq x|\text{Effort}=H) < Prob(X \leq x|\text{Effort}=L)$ for $x>0$, where the random variable X denotes catch.

oil, access to necessary facilities ashore, etc). The supply of capital involves knowledge of institutions, of investment funds, banks, tax rules, direct and indirect regulations of various kinds, in addition to knowledge of the usefulness of a specific type of gear and vessel, in given waters, for fishing the species of fish intended.

The contracting agents have to choose a remuneration system. In this paper three systems will be considered: the fixed-wage system, the share system and a combination of those two systems.

Under a *fixed-wage system*, the vessel-owner pays the skipper a fixed wage at the end of the contract period, independent of the results of the production process, i.e. the catch. If the catch does not reach a certain level (to be defined in more detail shortly), the vessel owner will suspect that the skipper has supplied a low level of effort and will not renew the contract for the following period. A skipper who has been discharged in this manner will not be rehired by another vessel owner in the period immediately following, but may or may not be hired in later periods.[9] When unemployed, the skipper's income will be equal to the unemployment insurance he is entitled to receive. Hence, the fixed-wage system has the elements of an *efficiency wage.*

Under the *share system* the skipper and the vessel-owner share the value of the catch. A skipper on share contract may be fired in the same manner as a skipper on a fixed-wage system.[10]

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[9]Other vessel owners might belief that a fired skipper was incapable of supplying high levels of effort. In that case a fired skipper would never get a new skipper contract. A second possibility is that vessel owners believed a fired skipper to be lazy. It would then depend on their believes with regard to "rehabilitation" of lazy skippers if a fired skipper would regain a contract or not.

[10]Avoiding low catch is of cause much more important for a skipper than just to avoid being fired. "Competition among skippers relates first of all to vessels and fishing space, and other factors of obvious relevance for production and success. While the connection between competition and financial success may not always be apparent, as in the case of the fight over the title of "king", prestige is not simply a matter of personal satisfaction or of winning in a competitive game. It is, rather, a matter of central economic importance in determining chances for future success. Prestigious skippers tend to have larger vessels, more sophisticated equipment and sounder financial backing. If the skipper improves his position, he has a

Under a *combined fixed -wage and share -wage system,*. the skipper's remuneration is partly in the form of a fixed wage and partly in the form of a share wage. A skipper on a combined contract may be fired if his performance is not satisfactory.

We shall, in the following paragraphs, consider how the skipper solves the problem of maximizing his life-time utility depending on the size of the fixed wage and/or the size of the share rate.

The skipper's problem

A skipper possesses fishery-specific skills and supplies effort. Both these variables are multi-dimensional and hard to define.[11] Skipper skills consist, among other things, of knowledge of the area where fishing is conducted, knowledge of where fish goes to spawn and feed and if such behavior is influenced by environmental factors, such as the temperature of the water or the salinity of the sea. Fishing effort consists of time and other resources spent on information gathering on- and offshore, time and money spent on searching for fish, time spent on the fishing activity itself, etc.

In what follows fishing effort will be treated as a one-dimensional variable which is fully controlled by the skipper. All skippers will be treated as if they commanded the same skills. Fishing is conducted over seasons or periods.

Catch varies stochastically, but expected catch is influenced by the effort supplied by the skipper. Hence, the expected catch of a skipper conditioned on effort supply, $E(X|e)$,

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chance of commanding a larger vessel, which is an important component in fishing success. If, on the other hand, he has a low position he risks losing his job. One of the Sandger›i skippers with the lowest prestige was fired at mid-season by his company because "he did not fish enough"." (Pálsson, 1991, p. 126).

[11] Skipper effects and skills have been discussed to some extent in the literature of anthropology of fishing. See Acherson (1981), Pálsson (1991) and Thorlindsson (1988). One of the issues debated are if differences in observed fishing success is the result of luck or acquired or innate skipper specific skills.

increases as supply of effort increases. Here X is catch, E is the expectational operator, and e is a measure of skipper effort.[12]

As X varies stochastically an absent vessel-owner will not know if a “poor” realization, x of X, is due to bad luck or to low effort on the part of the skipper. If supply of effort reduces skipper utility and if skippers are paid a flat wage, the following strategy is tempting for the skipper: to minimize his supply of effort, claim the fixed wage and explain any possibly low catch by the erratic nature of the fishing enterprise. The vessel-owner has several solutions to choose between. One is to monitor skipper input on board a fishing vessel by putting controllers on board. That is costly, and probably inefficient, as is best illustrated by the ever present-question of “who should control the controllers”.[13] Bowls and Ginits suggest that employers solve this problem by utilizing the repetitiveness of the exchange between an employee and an employer, or in our case between the skipper and his vessel owner. If an employee does a good job he will get his engagement renewed, if an employer is not satisfied with the quality of the job done or the efficiency with which an employee does a job, the employee does not get his work contract renewed. Consequently, renewal of work contract is contingent upon the employee’s input of effort.

It this is applied to fisheries, it means that a vessel-owner will not re-engage a skipper who brings an unusually small catch to shore in any given period.

As stated above skippers and vessel-owners negotiate a contract for one period at a time. Hence, the skipper use of effort, the wage or share offered by the vessel-owner, and

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[12] Here, expected catch is supposed to hinge on unobervable environmental factors and on unobservable skipper supplied effort. Vessel owners supply capital equipment. I find it natural to assume that skippers can observe all qualities of the vessel. Hence, I find it more appropriate to model the situation as one-sided moral hazard problem, than as double-sided moral hazard problem. For a review of recent advances in solution of double sided moral hazard problems, see Bhattacharyya and Lafontaine (1995).

[13] There are many other reasons why it will be inefficient for vessel owners to put controllers on board. One is question of authority. The skipper is commander-in-chief. What is the status of a controller? Can he command the skipper to keep on fishing if the skipper has decided not to?

other important variables are fixed for one period ahead each time. This can be defined as follows:

$$Prob(X \leq \hat{x} \mid e = \tilde{e}) \;=\; F(\hat{x} \mid \tilde{e}) \tag{3.1}$$

Here $F(\hat{x} \mid \tilde{e})$ is the cumulative probability function associated with the probability that catch is less than $\hat{x}$ conditioned on the event that effort is $\tilde{e}$. I will assume that $F_e(\hat{x} \mid \tilde{e}) < 0$ which implies that the probability of low catch is reduced as effort is increased, and that $F_{ee}(\hat{x} \mid \tilde{e}) > 0$ which implies that an increase in effort has a diminishing effect on the probability of low catch. Furthermore, I assume that $F_x(\hat{x} \mid \tilde{e}) > 0$, which implies that the probability of "too low" catch is increased as the threshold is increased. Lastly, I will assume that $F_{ex}(\hat{x} \mid \tilde{e}) < 0$, so that an increase in the threshold $\hat{x}$ has less influence on the cumulative probability function when effort is high than when effort is low.

At the end of a season the skipper receives pay (*I*) from the vessel owner. Instantaneous skipper utility can be written as:

$$U = I - g(e) \tag{3.2}$$

The function *g*(*e*) reflects the (monetarized) disutility that the skipper derives from supply of effort. The effort index (*e*) is normalized so that minimum effort equals zero.[14] It will be assumed that the first and second derivatives of this function are positive and furthermore that *g*(0)=0.

Skipper income consists either of a share wage, a fixed wage or a combination of the two:

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[14] The skipper must supply some minimum effort in order to keep the vessel and its crew safe from immediate dangers.

$$I = \alpha X + W \tag{3.3}$$

Here the parameter α reflects the skipper's share of revenue while W is the fixed wage. If the skipper is remunerated by a pure share wage, then W=0 and α>0. If the skipper is remunerated by a pure fixed-wage contract, then$W$>0 and α=0. Obviously, if the skipper is remunerated by a combination of fixed wage and share, both parameters are positive. I assume that skippers bring catch ashore at the end of a period and that share or wage is then paid. Hence the present value of the expected utility of a person who starts out as skipper at the beginning of period t (denoted as V_t) can be written as:

$$V_t = \beta\left[\alpha E(X|\tilde{e}) + W - g(\tilde{e})\right] + \beta\left[F(x^f|\tilde{e})V^b_{t+1} + \left\{1 - F(x^f|\tilde{e})\right\}V_{t+1}\right] \tag{3.4}$$

Here $\beta = \dfrac{1}{1+r}$ is the discount factor, r is the skipper's rate of time preference, and $\hat{V}$ is the expected lifetime utility of a skipper who loses his position as skipper. The parameter $\hat{V}$ will also be referred to as skipper reservation utility. A skipper will lose his position if his catch is less than the (vessel-owner-defined) quantity x^f. [15] In an steady state situation we thus have :

$$V_t = V_{t+1} = V \tag{3.5}$$

Substituting from (3.5) in (3.4) and simplifying yields:

[15] The model is formulated as if the skipper knows the cut-off, or threshold value, *xf*, for sure. This needs not to be correct. The vessel owner could of cause announce this value. But such announcement are rare. Hence, the skipper must form expectations about his vessel owners *xf*. Formulating such expectations can be a complicated matter and will be left out here.

$$V = \frac{\alpha E(X|\tilde{e})}{1+r} + \frac{W}{1+r} - \frac{g(\tilde{e})}{1+r} + \frac{F(x^f|\tilde{e})}{1+r}\hat{V} + \frac{1-F(x^f|\tilde{e})}{1+r}V \qquad (3.6)$$

A skipper who loses his contract will enjoy expected lifetime utility, from the time of dismissal, that is equal to his lifetime income in alternative employment, $\hat{V}$.[16] All the determinants of skipper lifetime utility are represented in (3.6). The problem of the skipper is to choose his level of effort so as to maximize the monetarized utility, *V*.

Skippers will supply effort so as to find the optimal solution to following problem:

$$\underset{e\geq 0}{Max}\, V = \frac{\left[\alpha E(X|e) + W - g(e) + F(x^f|e)\ \hat{V}\right]}{r + F(x^f|e)} \qquad (3.7)$$

The first order condition for solution of (3.7) is that:

$$\frac{\partial V}{\partial e} = \frac{\left[\alpha \frac{\partial E(X|e)}{\partial e} - g'(e) - F_e(x^f|e)\ \{V - \hat{V}\}\right]}{r + F(x^f|e)} = 0 \qquad (3.8)$$

It will be assumed that the second order condition for local maximum is fulfilled. Hence, *D* defined by (3.9) must be negative:

$$D = \left[\alpha \frac{\partial^2 E(X|\tilde{e})}{\partial e^2} - g''(\tilde{e}) - F_{ee}(x^f|\tilde{e})\ \{V - \hat{V}\}\right] \qquad (3.9)$$

[16] The size of $\hat{V}$ will, in general, hinge on the size of unemployment benefit accruing to unemployed skippers, the probability that a fired skipper will find a new job as skipper, the probability that a fired skipper will find employment in a different line of activity, the size of pay in such activities, the average spell of time that a fired skipper will have to wait for a new job, etc.

Here $\tilde{e}$ is the optimal level of effort. Condition (3.8) defines supply of skipper effort as a function of the vessel-owner-controlled variables α, W and x^f.

Condition (3.8) can be written as:

$$g'(e) = \alpha \frac{\partial E(X|e)}{\partial e} - F_e(x^f|e) \ \{V - \hat{V}\} \tag{3.10}$$

Hence, equation (3.8) predicts that the skipper will balance the disutility of increasing effort [represented by the term $g'(e)$] and discounted additional income accruing due to the increased effort. Income accrues to the skipper both directly and indirectly: it accrues directly, as increased effort positively increases revenue, of which the skipper is entitled a share. This effect is represented by the first term on the right hand side of (3.10). But income also increases indirectly, since as effort is increased the likelihood that the catch will be low is reduced. Consequently, the likelihood that the skipper will be fired due to inadequate catch is also reduced. A skipper who stays employed earns more than a skipper who is fired, and the difference in lifetime income, the skipper rent, is $V - \hat{V}$. This latter effect is represented by the second term on the right hand side of (3.10).

Assume, for the sake of illustration, that a skipper is remunerated by a fixed wage only, so that the revenue share is equal to zero. Then, if the expected lifetime earnings of a skipper were equal to his expected lifetime earnings in other occupations (so that $V = \hat{V}$), the skipper would only supply minimum of effort. The skipper would not lose in terms of lifetime income if he were fired. Consequently, he would not do anything extra to keep his job as skipper. This result is similar to results derived in ordinary efficiency wage models.

Assume, also for the sake of illustration, that effort is to be kept at a given level, e^* say. Equation (3.10) then shows that effort can be kept at e^* with different combinations of size of the skipper rent, $V - \hat{V}$, and the size of the revenue share parameter, α. We should note specificially that the lower the share parameter is, the higher the skipper rent must be if effort is to be kept at a constant level.

Implicit derivation of (3.8) with respect to the share parameter yields:

$$\frac{Me}{M\alpha} = \frac{1}{-D}\left[\frac{ME(X\,|\tilde{e})}{Me} - \frac{F_e\left(x^f|\tilde{e}\right)}{r+F\left(x^f|\tilde{e}\right)}\,E(X\,|\tilde{e})\right] > 0 \qquad (3.11)$$

Thus, skippers will react to any increase in the share parameter by increasing effort. The disutility of increasing effort is compensated for directly with higher income for a given level of catch. This higher income also widens the gap between expected income as skipper and expected income in alternative employment. The cost of losing a job as skipper is thus higher than before. Hence, the increased disutility of supplying more effort is partly paid for by the reduced risk of suffering a loss of income due to dismissal.

Implicit derivation of (3.8) with respect to the fixed-wage parameters yields:

$$\frac{Me}{MW} = \frac{1}{-D}\left[-\frac{F_e\left(x^f|\tilde{e}\right)}{r+F\left(x^f|\tilde{e}\right)}\right] > 0 \qquad (3.12)$$

Consequently, a skipper will also react to an increase in the fixed-wage parameter by increasing effort. A higher fixed skipper wage widens the gap between expected income as skipper and expected income in alternative employment, thus compensating for the increased disutility connected with increased supply of effort.

We can combine the results given by (3.11) and (3.12) in the following way:

$$\frac{Me}{M\alpha}\ \frac{\alpha}{e} > \frac{Me}{MW}\,\frac{W}{e}\ \ \frac{\alpha E(X\,|e)}{W} \qquad (3.13)$$

Hence, if the skipper receives half of his income from the share wage and half from the fixed-wage component of the remuneration contract, so that $\alpha E(X \mid \tilde{e}) = W$, then he will react more strongly, in terms of effort supplied, to a 1% change in the share parameter, than to a 1% change in the fixed wage. In both cases, increased skipper-income will make it more costly for the skipper to lose his job. But an additional effect is present if the share parameter is increased. The higher share parameter increases the portion of the marginal product that accrues to the skipper. Thus, the skipper reacts just like a firm experiencing higher price for its product, by producing more and demanding more inputs. This last effect is not present if only the fixed-wage component of the remuneration package is increased.

Lastly note that:

$$\frac{Me}{Mx^f} =$$

$$\frac{1}{-D}\left[-F_{ex}(x^f|\tilde{e})[\,V-\hat{V}\,]+\frac{F_e(x^f|\tilde{e})}{(r+F(x^f|\tilde{e}))}\left\{V\,F_e(x^f|\tilde{e})\;-\hat{V}F_x(x^f|\tilde{e})\right\}\right] > 0 \tag{3.14}$$

Given earlier assumptions regarding the sign of the first and the second derivatives of the *F*(.,.) function, an increase in x^f will increase the skipper supply of effort. If the threshold value, x^f, is increased it becomes harder for the skipper to gain contract renewal. In the event that the skipper belives that the threshold value, x^f, has been increased can restore the situation by increasing his supply of effort.

The problem of the vessel owner

The vessel owner's problem is to design a contract that prescribes the size of the remuneration parameters, α, W and the threshold value of acceptable catch, x^f. The profit of the vessel owner is, of course, affected by the remuneration contract offered and the resulting choice of skipper effort level. The vessel owner must also take into account that fired skippers must be replaced. Hiring and firing of skippers is not without cost; newly hired skippers must be trained and taught, and firing of skippers may involve cost as well. If we assume that the cost of firing and hiring one skipper is *h*., then using the same framework as for the skippers (and ignoring capital costs), and assuming that income accrues at the end of each period, while firing costs accrue at the beginning of a period, we can write the vessel owner's problem as follows:

$$\underset{\alpha, W, x^f}{Max}\,\Pi = \frac{\left[(1-\alpha)E(X|e) - W - hF\left(x^f|e\right)\right]}{r} \tag{3.15}$$

s.t.

i) $e = e\left(\alpha, W, x^f\right)$

ii) $V \geq \hat{V}$

iii) $\alpha \geq 0$

iv) $W \geq 0$

v) $x^f \geq 0$

The constraint (3.15)-i) enters the problem as vessel owners take skipper reaction to any change in the remuneration parameter into account. The second constraint is a skipper participation constraint. Skippers will not participate in fishing if the discounted value of expected utility (V) in fisheries is lower than the discounted value of expected utility in other occupations ($\hat{V}$). The third and the fifth constraints imply that the revenue share and the catch requirement must be non-negative numbers. The fourth constraint implies that the fixed-wage component of the remuneration package must be non-negative. This implies that we do not consider it possible for skippers to pay a fee for the opportunity of taking a vessel to the fishing ground. This could be the result of skippers' union activity, or it could be the result of vessel owner considerations that are absent in the model as presented (see Section 9 for further elaboration of this point).

Define:

$$G_B = (1-\alpha)\frac{ME(X|e)}{Me} - hF_e(x^f|e) \qquad (3.16)$$

G_B is a measure of the immediate benefit gained by the vessel owner when the skipper increases his supply of effort. The vessel owners gain on two accounts. Firstly, because increase in effort increases expected catch. Secondly, because increase in effort reduces the probability that the skipper has to be fired, thus saving expected firing and hiring costs. Hence, G_B is positive.

The Kuhn-Tucker conditions for the problem of the vessel-owner are presented in Appendix A. In that Appendix the question of what remuneration parameter mix the vessel owner can or will offer is considered. The conclusions are contained in the following table:

Table 1: Remuneration parameter mix offered by the vessel owner		
	Fixed-wage parameter	
Share parameter	W=0	W>0
$\alpha = 0$	Will not attract skippers	Contradicted
$\alpha > 0$	Not contradicted	Contradicted

Hence, the only remuneration parameter mix that vessel owners will offer is pure share contract. To understand that result it is helpful to draw skipper utility-contours and vessel-owner profit-contours in a remuneration-parameter space. The slope of the profit contour is given by:

$$\left.\frac{dW}{d\alpha}\right|_{\Pi=constant} = -\frac{G_B\frac{\partial e}{\partial\alpha} - E(X|e)}{G_B\frac{\partial e}{\partial W} - 1} = -E(X|e)\,\frac{\frac{G_B\frac{\partial e}{\partial\alpha}}{E(X|e)} - 1}{G_B\frac{\partial e}{\partial W} - 1} \qquad (3.17)$$

The slope of the skipper utility-contour is given by:

$$\left.\frac{dW}{d\alpha}\right|_{V^G=constant} = -E(X|e) \qquad (3.18)$$

This contour is always downward-sloping.

The contours are plotted in the parameter space in Figure 1. When the contours are plotted the following facts must be observed: 1. A utility contour and a profit contour will not be tangential . 2. A profit contour can have the same slope as the share parameter axis. 3. A utility contour will always intersect a profit contour from above.

If Fact 1 was not true, then an internal solution with positive revenue share and a positive fixed wage would be possible. Hence, those contours cannot be tangential. Fact 2 follows from the first order conditions for the vessel owner: The first order condition of unconstrained profit maximum is only fulfilled when the nominator of (3.17) is equal to zero. Hence, unconstrained profit maximum is not possible except when Fact 2 is true. Then to Fact 3: If the utility of a skipper is to be kept constant, any loss in the size of the revenue share must be compensated by an increase in fixed wage. In some cases if the size of the revenue share is increased then the profit of a vessel owner increases so that the fixed wage must be increased if profit is to be kept at a given level. In other cases an increase in the size of the revenue share would reduce profits, implying that vessel owners would have to compensate by paying a lower fixed wage to skippers if their own profits were to be kept constant. Fact 3, is proven in Appendix 3. Suppose that skipper utility is to be increased by one unit. Fact 3 says that profit lost will be less if this utility increase is achived by appropriate increase in the revenue share than if achived by appropriate increase in the fixed-wage rate.

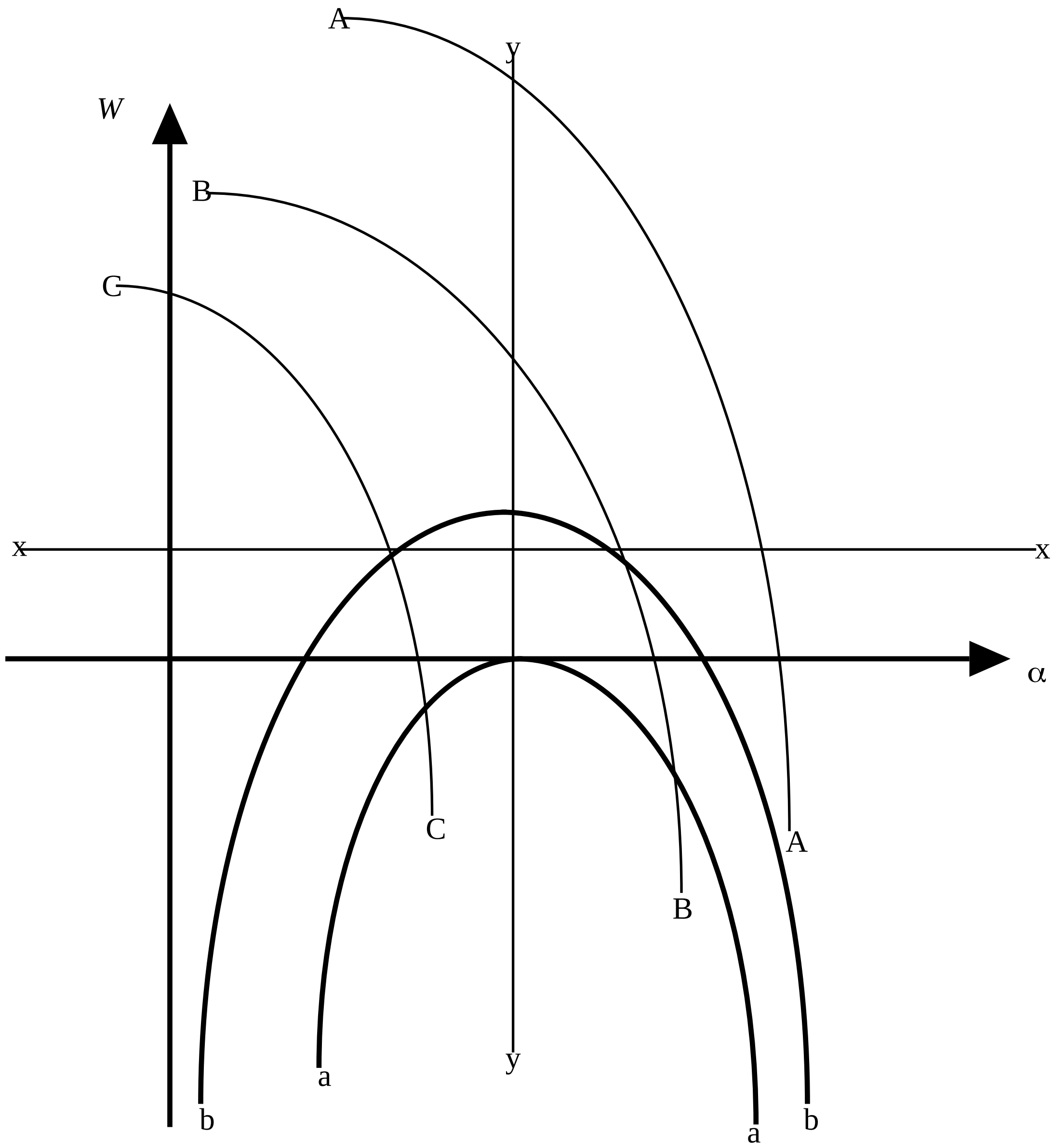

Figure 1 Utility contours of skippers are represented by the curves AA, BB and CC. The curve AA represents higher level of utility than does the curve BB etc. Profit contours of vessel owners are represented by the curves aa, and bb. The curve aa represents a higher level of profits than does the curve bb. Movement to the right along the line ii represents an incresing revenue share but a constant fixed wage. Movement upwards along the line yy represents higher and higher fixed wage but a constant revenue share.

If we assume that as the share parameter is increased the fixed wage parameter is kept constant, for instance, along the line xx on Figure 1. The skipper will react to such a change by increasing effort. The enhanced skipper supply of effort increases catch and skipper income. For low levels of the share parameter the vessel owner profit will increase also, as the total catch increases more than the equivalent of the increase in income accruing to the skipper. For higher values of the share parameter the cost of increasing the share parameter eventually exceeds the additional revenue created by increased skipper effort. A unilateral increase in the fixed wage (for instance along the line yy on Figure 1) will only reduce vessel-owner profits.

A unilateral increase in either the revenue share or the fixed wage will always increase skipper utility.

In the next section we shall consider how the vessel owner determines the share parameter.

4 Vessel owner decisions

We have to allow for two different possibilities when considering the vessel owner's decision regarding the remuneration parameters. The first case implies that the skipper participation constraint is not binding, so that the vessel owner can choose the remuneration parameters without considering the level of skipper utility that implicitly is implied. The second case covers the situation when the vessel owner has to take the skipper participation decision into account along with considerations of the profits of his own operation.

Vessel owner choice of share parameter when skipper participation constraint is not binding

In this case the vessel owner can decide the remuneration parameters so as to maximize profits and only has to observe the non-negativity restriction on the parameters. This situation is depicted in Figure 2:

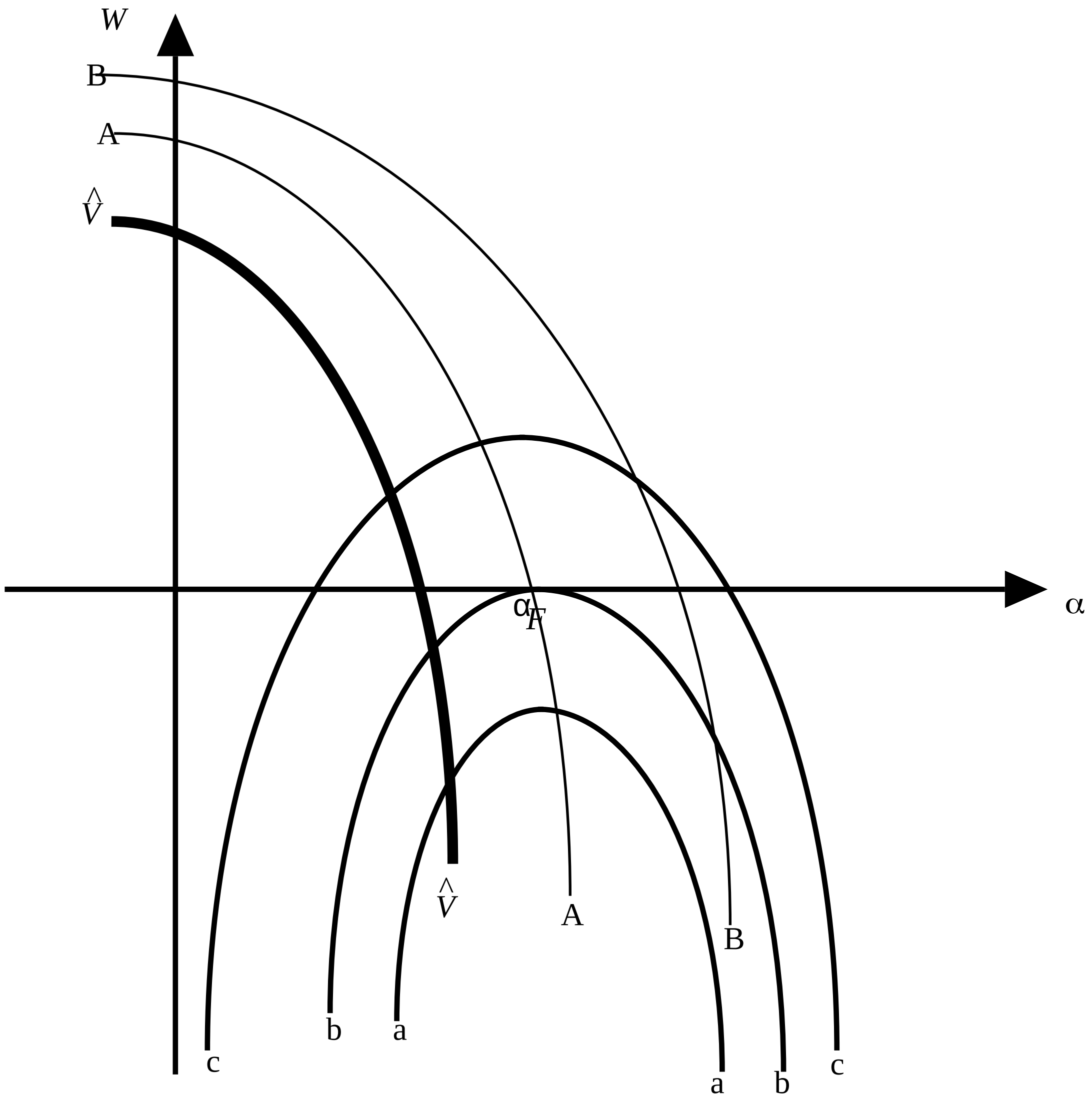

Figure 2 Vessel owner chooses non-negative remuneration parameters freely. Choosing W=0 and $\alpha=\alpha_F$ yields highest possible profit for the vessel-owner.

In this case the vessel owner will do best if he chooses the share parameter so that his profit contour is tangential to the α axis. In the figure that implies the choice of α_F as the share parameter. Any other choice would imply a lower level of profit for the vessel owner, as bb is the highest profit contour that the vessel owner can reach without breaking the non-negativity requirement for the remuneration parameters.

It should be noted that the vessel owner will not alter his choice of share parameter in the face of changes in skipper reservation utility, for instance, as long as such change does not make α_F an inadmissable choice. Changes that affect vessel- owner profits will on the other hand affect choice of share parameter. Hence, if the relationship between expected catch and skipper supply of effort changes, a change in the share parameter is warranted.

Vessel owner choice of share parameter when skipper participation constraint is binding

In this case the vessel owner must take into consideration that he may offer a remuneration package so poor that the skipper finds it more profitable to seek alternative employment . The vessel owner is more restricted in his choice of remuneration parameters here than in the former case. This situation is represented in Figure 3:

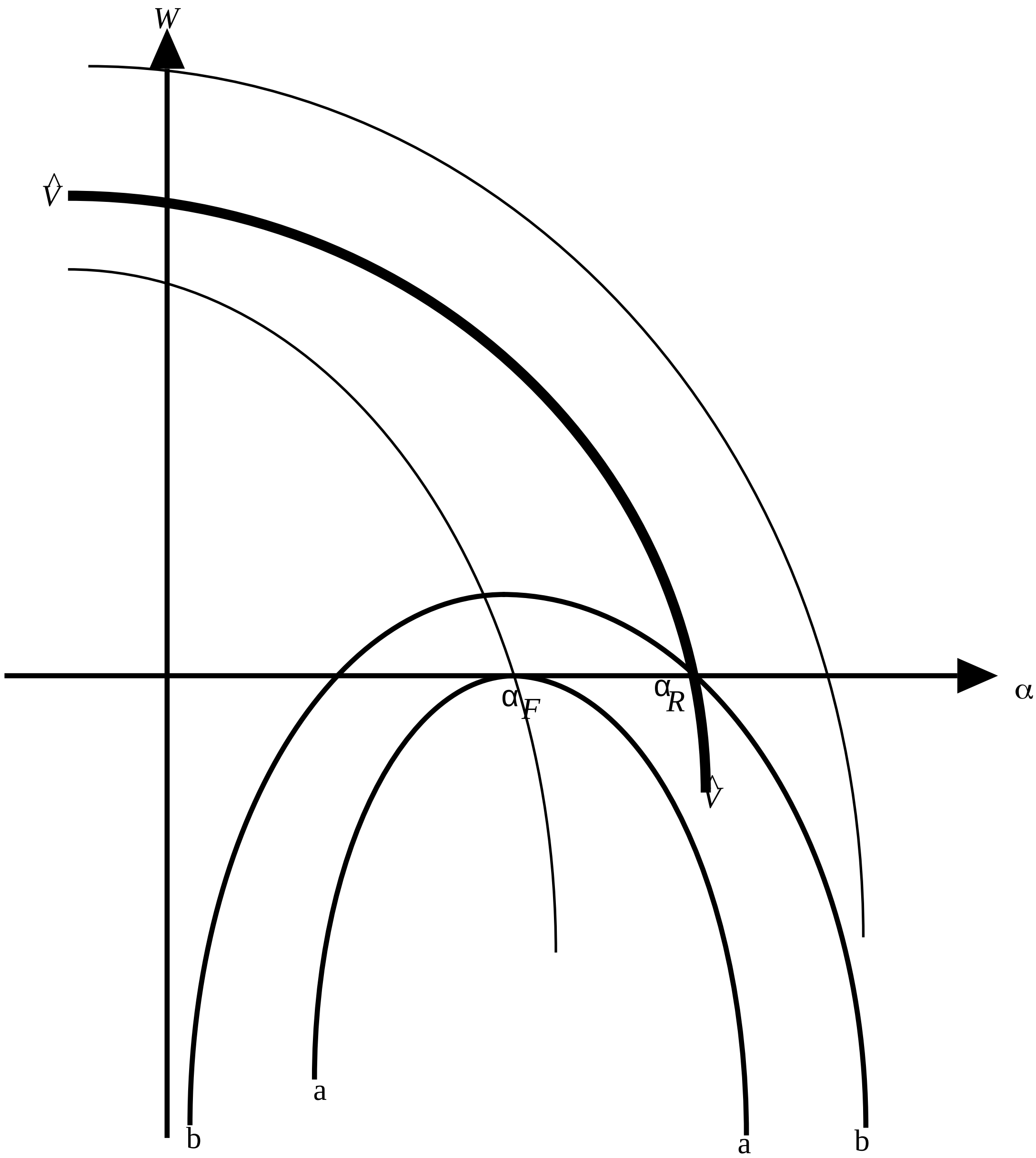

Figure 3 Vessel owner determination of remuneration parameters when skipper participation constraint is binding. The line *VV* represents the skipper participation constraint. Skipper will not accept contracts that involve parameter constellations on left of that line. The highest profit contour that the vessel owner can reach without violating that requirement is cc. The best choice of remuneration parameters is to set W=0 and $\alpha=\alpha_R$.

In this case the share parameter offered is determined by the point where the participation constraint $\hat{V}$ crosses the α-axis. If the vessel owner were to set the share parameter higher than α_R on the figure his profits would be lowered. If he tried to set the share parameter lower he would violate the skipper participation constraint. This would be true in particular?? if the vessel owner tried to set the share parameter equal to α_F.

If the skipper participation constraint is binding, the share parameter will not be altered in the face of changes that only affect the profit contours. But the share parameter will be altered by changes that affect skipper reservation utility, $\hat{V}$. Hence, a change in the dis-utility of work or in the unemployment benefit will affect the share parameter.

According to the model and the restrictions put on the remuneration parameters, vessel owners will offer pure share contracts. Vessel owners will not offer pure lump-sum fixed-wage contracts or contracts that mix a positive fixed-wage and a positive share of output. This conclusion holds even in a model where skipper-contract renewal is contingent on the performance of the skipper.

If the skipper participation constraint is binding, the share parameter will be affected by changes in wages in other parts of the economy, as such changes will almost certainly affect the placement of the $\hat{V}$-contour. But changes that only affect the profit contour of the vessel owner will not affect the share parameter offered. If the skipper participation constraint is not binding, the share parameter will not be affected by changes in unemployment benefit or other changes that might affect skipper utility. But changes that affect the slope or the placement of a vessel-owner profit contour would affect the choice of share parameter.

How does all this relate to sharing systems actually in use? We can take the Icelandic sharing system as an example. The revenue share accruing to crews on a given vessel using specific gear and operating with a given number of crew members is represented by $r=a\cdot b$, where a is specific to each category of vessel using specific gear. The parameter b is common for all vessels and all gear and is changed each month according to the price of oil at the world market. The fishery specific parameters, the a's, seem to be constant for long spells of time. When new gear is introduced or when new equipment is installed in the vessel, thus reducing the need for labour, a new fishery-specific parameter is negotiated. The universal parameter is constantly being modified, either because of changes in the price of fuel or because new a formula for the parameter is negotiated in collective bargaining agreements.

Hence, the Icelandic system is consistent with our model - given that the skipper participation constraint is not binding. When gear is changed, or the number of crew members adjusted, a change in profit contours results. This brings a need for the renegotiation of share parameters. On the other hand, if such factors are left unchanged, no change in the share parameter is warranted.

5 Concluding remarks

Our conclusions also show that the restriction that the fixed wage be non-negative is costly for the vessel-owner. Hence, if the vessel owner could set the fixed-wage variable freely he would choose some negative value for this variable. I.e. the vessel owner would prefer to rent the fishing-vessel project to the skipper. Income accruing to the vessel owner would come from two sources: a) fixed rent for the vessel and b) a share of revenue. The vessel owner would, of course supply the vessel, etc. Such arrangements are sure to exist, even if they are not widespread. But why is the general rule of remuneration in fisheries that of share contracts and not of project renting? The most likely reason is that project renting will depress average skipper income below what skippers' unions might find acceptable. Assume that there are more skippers than vessels. Then vessel owners could decide to engage the skipper who offers the highest rent for a given revenue share. In equilibrium, skippers would offer to pay so high a rent that the expected utility gain from participating in the fishery would be almost zero. Hence, restricting possible contracts so that skippers are prohibited from offering a rent for taking a fishing vessel to the fishing ground may increase the utility of the skippers that participate in the fishery. It is obvious that a single skipper will not be able to establish or enforce such a rule. But a skippers' union is fully capable of doing that.

The earlier argument against share contracts was based on their static incentive effects. What does the model presented abovehave to say on that issue? Earlier we asked whether a fixed-wage contract, where contract renewal was contingent upon an acceptable performance in the preceding period, could be as good or even better than a share contract as an incentive instrument . The answer to that question is clearly no. Share contracts outperform fixed-wage contracts in an environment where vessel owners fix the remuneration parameters at their own discretion. A vessel owner has the threat of not renewing a contract with a skipper whether the skipper is on a share contract or a fixed-wage contract. Hence, under either remuneration regime, a vessel owner would have the power to punish a skipper who does not perform to his satisfaction. Hence, the negative consequence of bad performance are present in both regimes. But, in the case of a share regime, a positive consequence of good performance is added. Good catch implies higher income.

My model predicts that vessel owners will find it more economical to offer a pure share contract than to offer a pure wage contract or a mixed contract. The reason for this result is that skippers on a share contract will work harder at any given level of wage costs accrued by the vessel owner. A hard-working skipper will, on average, supply more catch than will one who does not work as hard.

The model is also capable of explaining under which circumstances changes related to vessel-owner profit influence the share ratio and under which circumstances changes related to skipper-utility influence that ratio. The situation in Iceland is such that changes in vessel-owner profitability influence the development of the share ratios, indicating that skippers are remunerated well in excess of their reservation wage.

The model does not explain directly why there are income guarantees in the negotiated share systems in Iceland. When discussing the optimal effort choice by skippers in Section 3 we noted that low skipper rent and high revenue share could induce the same skipper effort as low (zero) revenue share and a higher skipper rent. Hence, one of the effects of the revenue share remuneration system, as compared to a fixed salary system, is that the employer (the vessel owner) is able to confiscate some of the skipper (employment) rent that would have accrued if unchanged skipper-effort were to be induced by a fixed salary remuneration system. Consequently, labour unions in the fishery sector should be reluctant to accept revenue sharing without some form of compensation for the “confiscated” employment rent. The income guarantee may be one way in which this compensation is made.

This paper started out by asking why remuneration by sharing is more common in fisheries than in other industries. It may be more appropriate, however, at the end of this investigation to ask: Why is sharing not used as the dominant form of remuneration in other industries than fishing? A possible answear is that labour unions in other industries have not been able, to the same extent as labour unions in the fishery sector, to find methods to compensate for “confiscation” of employment rents. A second reason is connected to the fact that the models we have developed indicate that sharing is superior to other forms of remuneration when the expected production and worker effort and worker remuneration are positively related. All these prerequisites seem to be fulfilled in the case of the fisheries. The production unit is well-defined and the product is usually also well-defined. Effort use yields immediate results. Those links may be less obvious in other industries where the time lapse from effort input until output is produced may be months or years and where output may be harder to define (as in many service industries). Hence, in industries other than fishing, it may be worthwhile for employers to try to develop other remuneration systems.

The question that was put forward in the introduction of this paper was: Why do vessel owners remunerate their crews by shares? The answer offered by the model of this paper is threefold: Firstly, because it is profitable for vessel owners. Secondly, because the product and manpower use connected to any given fishing trip is easily defined. Thirdly, because the unions in the fishing sector seem to have been able to strike an acceptable balance with employers with respect to the distribution of employment rents.

Appendix A: Derivation of results in Table 1

The vessel owner's problem is to:

$$\underset{\alpha, W, x^f}{Max}\,\Pi = \frac{\left[(1-\alpha)E(X\,|e) - W - hF\left(x^f|e\right)\right]}{r} \qquad \text{(A1)}$$

s.t.

i) $e = e\left(\alpha,\, W, x^f\right)$

ii) $V \geq \hat{V}$

iii) $\alpha \geq 0$

iv) $W \geq 0$

v) $x^f \geq 0$

The parameters $\lambda,\ \mu,\ \gamma\ \geq 0$ are the Lagrange parameter associated with (A1)-ii),(A1)-iii) and (A1)-iv) respectively. Further, we have defined:

$$G_B = (1-\alpha)\frac{\partial E(X\,|e)}{\partial e} - h\,F_e\left(x^f|e\right) \qquad \text{(A2)}$$

G_B >0 is a measure on the immediate benefit gained by the vessel owner when the skipper increases his supply of effort infinitesimally.

Now the Kuhn-Tucker conditions for the problem of the vessel-owner can be written as:

$$\frac{1}{r}\left[G_B\frac{\partial e}{\partial \alpha} - E(X\,|\,\tilde{e})\right]+\lambda\frac{1}{r+F\left(x^f|\tilde{e}\right)}\,E(X\,|\,\tilde{e})+\mu\le 0 \tag{A3}$$

$$\frac{1}{r}\left[G_B\frac{\partial e}{\partial W} - 1\right]+\lambda\frac{1}{r+F\left(x^f|\tilde{e}\right)}+\gamma\le 0 \tag{A4}$$

$$\frac{1}{r}\left[G_B\frac{\partial e}{\partial x^f} - h\,F_x\left(x^f|\tilde{e}\right)\right]+\lambda\frac{F_x\left(x^f|\tilde{e}\right)}{r+F\left(x^f|\tilde{e}\right)}\left[\hat{V} - V\right]\le 0 \text{ or } x^f=0 \tag{A5}$$

$$\lambda\left(V-\hat{V}\right) = 0 \tag{A6}$$

$$\mu\alpha=0 \tag{A7}$$

$$\gamma W = 0 \tag{A8}$$

We consider the following cases:

Case 1: $V>\hat{V},\ W>0,\ \alpha>0$

In this case the conditions (A6)–(A7) imply that the Langrange parameters $\lambda,\ \mu$ and γ are zero so the first order conditions become:

$$\left[G_B\frac{\partial e}{\partial \alpha} - E(X\,|\,\tilde{e})\right] = 0 \tag{A9}$$

$$\left[G_B\frac{\partial e}{\partial W} - 1\right] = 0 \tag{A10}$$

$$\left[G_B \frac{\partial e}{\partial x^f} - h F_x\left(x^f | \tilde{e}\right) \right] = 0 \text{ or } x^f = 0 \qquad \text{(A11)}$$

Here $\tilde{e} = e\left(\tilde{\alpha}, \tilde{W}, \tilde{x}^f\right)$ indicates the supply of effort that would result from the choice of vessel-owner controlled variables as indicated. From (3.11) and (3.12) we have that:

$$\frac{\dfrac{\partial e}{\partial \alpha}}{E(X|\tilde{e})} > \frac{\partial e}{\partial W} \text{ when } \frac{\partial E(X|\tilde{e})}{\partial e} > 0$$

On the other hand if (A9) and (A10) are to be simultaneously fulfilled, then:

$$\frac{\dfrac{\partial e}{\partial \alpha}}{E(X|\tilde{e})} = \frac{\partial e}{\partial W}$$

Thus, (A9) and (A10) obviously contradict (7.8). Or, in other words, the vessel-owner cannot solve his problem by choosing a non-negative value for both the remuneration parameters.

Case 2: $V > \hat{V},\ \alpha > 0,\ \ W = 0$

In this case the fixed-wage parameter W is set at zero. Conditions (A6) to (A7) imply that $\lambda = \mu = 0$ are positive, while $\gamma = 0$. Hence, the first order conditions take the form:

$$\left[G_B \left.\frac{\partial e}{\partial \alpha}\right|_{W=0} - E(X|\hat{e}) \right] = 0 \qquad \text{(A12)}$$

$$\frac{\left[G_B \left. \frac{Me}{MW} \right|_{W=0} - 1 \right]}{r} + \gamma = 0 \tag{A13}$$

$$\left[G_B \left. \frac{Me}{Mx^f} \right|_{W=0} - F_x\left(x^f | \hat{e}\right) \right] = 0 \; or \; \hat{x}^f = 0 \tag{A14}$$

The conditions (A12) and (A13) together imply that:

$$\gamma = \frac{G_B}{r} \left(\frac{\frac{Me}{M\alpha}}{E(X|\hat{e})} - \frac{Me}{MW} \right) > 0 \tag{A15}$$

Here $\hat{e} = e\left(\hat{\alpha}, 0, \hat{x}^f\right)$ with $\hat{\alpha} > 0$ and the hat indicates that the variable is possibly one that solves the vessel-owners problem if the fixed-wage parameter is set atzero. The last inequality follows from (3.11) and (3.12). According to earlier assumptions $\gamma > 0$. Hence, if the skipper utility constraint is not binding, the vessel-owner's problem might be solved by choosing a positive share parameter and setting the fixed wage parameter equal to zero.

Note that (A14) can not be fulfilled with equality if $\frac{Me}{Mx^f} < 0$. If $\frac{Me}{Mx^f} < 0$ x^f will be set equal to zero.

Case 3: $V > \hat{V}$, $\alpha = 0$, $W > 0$

In this case the share parameter α is set at zero. Conditions (A6) to (A7) imply that $\lambda = \gamma = 0$ are positive, while $\mu > 0$. Hence, the first order conditions take the form:

$$\frac{\left[G_B \left. \frac{Me}{M\alpha} \right|_{\alpha=0} - E(X\,|\bar{e}) \right]}{r} + \mu = 0 \tag{A16}$$

$$\left[G_B \left. \frac{Me}{MW} \right|_{\alpha=0} - 1 \right] = 0 \tag{A17}$$

$$\left[G_B \left. \frac{Me}{Mx^f} \right|_{W=0} - h\,F_x\left(\bar{x}^f|\tilde{e}\right) \right] = 0 \; or \, \bar{x}^f = 0 \tag{A18}$$

The conditions (A16) and (A17) together imply that:

$$\mu = - \frac{G_B}{r} \left(\frac{\frac{Me}{M\alpha}}{E(\,X\,|\,\bar{e})} - \frac{Me}{MW} \right) < 0 \tag{A19}$$

Here $\bar{e} = e\left(0,\, \bar{W}, \bar{x}^f\right)$ with $W>0$ and the bar indicates that the variable is possibly one that solves the vessel owner's problem if the share-wage parameter is set at zero. According to earlier assumptions $\mu > 0$. According to (A19) this parameter must be negative, however. Hence, the vessel owner will not offer a pure fixed-wage contract in this case.

Case 4: $V = \hat{V},\; W > 0,\; \alpha > 0$

In this case the conditions (A6)–(A7) imply that the Lagrange parameters μ and γ are zero so the first order conditions become:

$$\frac{\left[G_B \frac{Me}{M\alpha} - E\left(X\,|\,\tilde{e}_{\hat{V}}\right) \right]}{r} + \lambda \frac{E\left(X\,|\,\tilde{e}_{\hat{V}}\right)}{r + F\left(x^f|\tilde{e}_{\hat{V}}\right)} = 0 \tag{A20}$$

$$\frac{\left[G_B \frac{\partial e}{\partial W} - 1\right]}{r} + \lambda \frac{1}{r + F\left(x^f | \tilde{e}_{\hat{V}}\right)} = 0 \tag{A21}$$

$$\frac{\left[G_B \frac{\partial e}{\partial x^f} - h\, F_x\left(x^f | \tilde{e}_{\hat{V}}\right)\right]}{r} = 0 \qquad \text{or} \qquad x^f = 0 \tag{A22}$$

Here $\tilde{e}_{\hat{V}} = e_{\hat{V}}\left(\tilde{\alpha}, \tilde{W}, \tilde{x}^f\right)$ indicates the supply of effort that would result from the choice of vessel-owner controlled variables as indicated. If (A20) and (A21) are to be simultaneously fulfilled, then:

$$\frac{\frac{\partial e}{\partial \alpha}}{E(X|\tilde{e})} = \frac{\partial e}{\partial W}$$

Thus, (A20) and (A21) obviously contradict (3.11) and (3.12). Or, in other words, the vessel owner cannot solve his problem by choosing a non-negative value for both the remuneration parameters.

Case 5: $V = \hat{V},\ \alpha > 0,\ \ W = 0$

In this case the fixed-wage parameter *W* is set at zero. Conditions (A6) to (A7) imply that $\mu = 0$. Hence, the first order conditions take the form:

$$\frac{\left[G_B \frac{\partial e}{\partial \alpha} - E\left(X | \hat{e}_{\hat{V}}\right)\right]}{r} + \lambda \frac{E\left(X | \hat{e}_{\hat{V}}\right)}{r + F\left(x^f | \hat{e}_{\hat{V}}\right)} = 0 \tag{A23}$$

$$\frac{\left[G_B \frac{\partial e}{\partial W} - 1\right]}{r} + \lambda \frac{1}{r + F\left(x^f | \hat{e}_{\hat{V}}\right)} + \gamma = 0 \tag{A24}$$

$$\frac{\left[G_B \frac{\partial e}{\partial x^f} - h F_x\left(x^f | \hat{e}_{\hat{V}}\right)\right]}{r} = 0 \quad \text{or} \quad x^f = 0 \tag{A25}$$

The conditions (A23) and (A24) together imply that:

$$\gamma = \frac{G_B}{r} \left(\frac{\frac{\partial e}{\partial \alpha}}{E\left(X | \hat{e}_{\hat{V}}\right)} - \frac{\partial e}{\partial W} \right) > 0 \tag{A26}$$

Here $\hat{e}_V = e_V\left(\hat{\alpha}, 0, \hat{x}^f\right)$ with $\hat{\alpha} > 0$ and the hat indicates that the variable is possibly one that solves the vessel owner's problem if the fixed-wage parameter is set at zero. According to earlier assumptions $\gamma > 0$. Hence, the vessel owner's problem might be solved by choosing a positive share parameter and setting the fixed wage parameter equal to zero in this case also. Note that x^f will be set equal to zero if $\frac{\partial e}{\partial x^f} < 0$.

Case 6: $V = \hat{V},\ \alpha = 0,\ W > 0$

In this case the share parameter α is set equal to zero. Conditions (A6) to (A7) imply that $\gamma = 0$. Hence, the first order conditions take the form:

$$\frac{\left[G_B \frac{Me}{M\alpha} \; - \; E\left(X \,|\, \bar{e}_{\hat{V}}\right) \right]}{r} + \lambda \frac{E\left(X \,|\, \bar{e}_{\hat{V}}\right)}{r + F\left(x^f | \bar{e}_{\hat{V}}\right)} \; + \; \mu \; = \; 0 \qquad \text{(A27)}$$

$$\frac{\left[G_B \frac{Me}{MW} \; - 1 \right]}{r} \; + \; \lambda \frac{1}{r + F\left(x^f | \bar{e}_{\hat{V}}\right)} \; = \; 0 \qquad \text{(A28)}$$

$$\frac{\left[G_B \frac{Me}{Mx^f} \; - \; h\, F_x\left(x^f | \bar{e}_{\hat{V}}\right) \right]}{r} \; = \; 0 \quad \text{or} \quad x^f \; = \; 0 \qquad \text{(A29)}$$

The conditions (A27) and (A28) together imply that:

$$\mu \; = \; - \; \frac{G_B}{r} \left(\frac{\frac{Me}{M\alpha}}{E\left(\, X \,|\, \bar{e}_{\hat{V}}\right)} \; - \; \frac{Me}{MW} \right) \; < \; 0 \qquad \text{(A30)}$$

Here $\bar{e} = e\left(0,\, \bar{W}, \bar{x}^f\right)$ with $W>0$ and the bar indicates that the variable is possibly one that solves the vessel owner’s problem if the share-wage parameter is set at zero. According to earlier assumptions $\mu > 0$. But according to (A30) μ must be less than zero. Hence, the vessel owner will not offer a pure fixed-wage contract.

Appendix B A proof of the statement that a skipper utility contour will always intersect a profit contour from above

From (A15) and/or (A26) it is clear that:

$$\frac{\partial e}{\partial \alpha} > \frac{\partial e}{\partial W} E(X|e) \tag{B1}$$

Multiplying with G_B>0 and subtracting $E(X|e)$ on both sides of the inequality sign yields:

$$G_B \frac{\partial e}{\partial \alpha} - E(X|e) > E(X|e)\left[G_B \frac{\partial e}{\partial W} - 1\right] \tag{B2}$$

Now, division on both sides of (B2) with $1 - G_B \frac{\partial e}{\partial W}$ which, according to (A13) and/or (A24) is positive, yields:

$$-\frac{G_B \frac{\partial e}{\partial \alpha} - E(X|e)}{G_B \frac{\partial e}{\partial W} - 1} > -E(X|e) \tag{B3}$$

Hence,

$$\left.\frac{dW}{d\alpha}\right|_{\Pi=constant} = -\frac{G_B \frac{\partial e}{\partial \alpha} - E(X|e)}{G_B \frac{\partial e}{\partial W} - 1} > \left.\frac{dW}{d\alpha}\right|_{V=constant} = -E(X|e) \tag{B4}$$

QED.

References:

Acherson, J.M. “Anthropology of Fishing.” *Ann. Rev. Antrhropol* 10 (1981): 275-316.

Anderson, Lee G. “The Share System in Open–Access and Optimally Regulated Fisheries.” *Land Economics* 58 (4 1982): 435-449.

Bai, Chong-en and Zhigang Tao. *Contract Mix and Ownership*. Boston Collage??, 1996.

Bhattacharyya, S. and F. Lafontaine. “Double-sided Moral Hazard and the Nature of Share Contracts.” *Rand Journal of Economics* 26 (4 1995): 761-781.

Bowles, S. and H.Ginits. “Contested Exchange: New Microfoundations for the Political Economy of Capitalism.” *Politics and Society* 18 (2 1990): 165-222.

Eswaran, M. and A. Kotwal. “A Theory of Contractual Structure in Agriculture.” *American Economic Review* 75 (3 1985): 352-367.

FitzRoy, Felix R. and Kornelius Kraft. “Profitability and Profit Sharing.” *Journal of Industrial Economics* 35 (Dec. 1986): 111-130.

Hansdottir, T. *Hlutaskipti í íslenskum fiskvei›um (Sharing in Icelandic Fisheries)*. University of Iceland, 1992. Unpublished manuscript.

Johnson, D. Gale. “Resource Allocation under Share Contracts.” *Journal of Political Economy* 58 (1950): 111-123.

Kraft, Kornelius. “The Incentive Effects of Dismissals, Efficiency Wages, Piece-Rates and Profit-Sharing.” *Review of Economics and Statistics* 73 (3 1991): 451-459.

Kruse, Douglas L. *Profit Sharing, Does it make a Difference?* Kalamazoo: W.E.Upjohn Institute for Employment Research, 1993.

Lazear, Edward P. “Salaries and Piece Rates.” *Journal of Business* 59 (3 1986): 405-431.

Levine, D. “Efficiency Wages in Weitzman's Share Economy.” *Economics Letters* 23 (1987): 245-249.

Levine, D. “Efficiency Wages in Weitzman's Share Economy.” *Industrial Relations* 28 (3 1989): 321-334.

Libenstein, H. “The Theory of Underemployment in Backward Economies.” *Journal of Political Economy* 65 (1957): 91-103.

Matthiasson, T. *Cost sharing and catch sharing.* Institute of economic studies(?? Ég held a› hún heiti ekki nákvæmlega fletta?), forthcoming. Working Paper Series.

Moene, Karl Ove. *Arbeidstempo og akkordsats : interne tilpasninger i en bedrift med interessemotsetninger*. Universitetet i Oslo, 1981. Memorandum.

Moene, Karl Ove. “Is Profit Sharing a Cure for Unemployment in Less Developed Countries?” *Journal of Development Economics* 33 (1990): 89-99.

Newbery, David M. G. “The Choice of Rental Contract in Peasant Agriculture.” In *Agriculture in Development Theory*, ed. Lloyd G. Reynolds. 109-137. New Haven and London: Yale University Press, 1975.

Pálsson, Gísli. *Coastal economies, cultural accounts : human ecology and Icelandic discourse.* Manchester: Manchester University Press, 1991.

Platteau, J.Ph. and J. Nugent. *Share Contracts and their rationale: Lessons from Marine Fishing.* Facultés Universitaires of Namur, University of Southern California, 1991.

Solow, R. “Another Possible Source of Wage Stickiness.” *Journal of Macroeconomics* 1 (1979): 79-82.

Stiglitz, J.E. “Incentives and Risk Sharing in Sharecropping.” *Review of Economic Studies* 21 (2 1974): 219–256.

Thorlindsson, T. “The Skipper Effect in the Icelandic Herring Fishery.” *HumanOrganization* 47 (3 1988): 199-212.

Weitzman, Martin L. and Douglas L. Kruse. “Profit Sharing and Productivity.” In *Paying for Productivity*, ed. Alans?? S. Blinder. Washington D.C.: The Brookings Institution, 1990.

Wilen, J.E. and K.Casey. *Impacts of ITQs on Labor: Employment and Remuneration Effects.* Department of Agricultural and Resource Economics, University of California, Davis, California, 1996. Paper prepared for Workshop on The Social Consequences of ITQ Management, Westman Islands, Iceland, May 25-26, 1996.

Zoeteweij, H. “Fishermen's Remuneration.” In *The Economics of Fisheries*, ed. R. Turvey and J. Wiseman. Rome: FAO, 1956.