Reciprocal Exposure and Holdup in Fisheries: Implications of Fishery Management Policy

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Abstract: The intermediate market for raw fish is characterized by time and space considerations that create significant quasi-rents between the fisher and the initial processor(s) approached to complete an exchange. This "temporal specificity" is more pronounced the fewer the number of alternative potential buyers, the more perishable the catch and the more geographically dispersed the alternative buyers. Owing to the costly strategic behavior that often accompanies large quasi-rents, "on-the-spot" negotiations are likely to result in a negative return for a fisher investing in technologies that lead to pronounced temporal specificity problems. An empirical study by Koss (1999) supports the hypothesis that reciprocal ex ante specific investment costs are incurred by some processors in order to reduce the probability of ex post holdup. This paper explores the implications that the above finding has for fishery management policies. In particular, if the goal of fishery management is to maximize the value of the fishery, then policy should not hinder the use of contractual tools that serve to accommodate or promote efficient transactions. The dilemma facing policy-makers, however, is that such tools often simultaneously lead to an increase in the concentration of market power among a small group of processors. Several existing policy alternatives are evaluated according to their tendency to accommodate or inhibit the use of reciprocal exposure to promote efficient exchanges.

1. INTRODUCTION

Economists have long recognized the existence of the hold-up problem: "the general business problem in which each party to a contract worries about being forced to accept disadvantageous terms later, after it has sunk an investment, or worries that its investment may be devalued by the actions of others (Milgrom and Roberts, 1992: 136). If either of the parties refuses to undertake the initial requisite investment(s), a potentially Pareto-improving exchange will not obtain; thus market failure occurs.

Williamson (1983), in developing his 'hostage model,' examines an intermediate product market in which self-enforcing agreements involve 'credible commitments.' He maintains that one way to avoid market failure is to expand the contractual relation by devising a *mutual reliance relation*. That is, the buyer may reciprocally invest in specific capital that has value only in servicing the final demands for the product in question. If the non-salvageable value of the advance commitment undertaken by the buyer equals that of the supplier, an efficient exchange result will emerge. Koss and Eaton (1997) formally demonstrate Williamson's contention that the efficiency of a contract may be endogenously enforced by a mutual reliance relation.

Koss (1999) empirically tests the importance of transaction-specific investments in determining contract choice in the intermediate market for raw fish. Contracts between fishers and processors in British Columbia for the 1988 fishing season are of two general types: spot-market arrangements, and *ex ante* agreements. With a spot contract, buyers and sellers of fish seek one another *after* incurring seasonal investments (e.g., vessel maintenance, crew, processing facilities, etc.); there is no prior agreement for exchange, nor is there an agreement the relationship will continue beyond the transaction.[1] With *ex ante* agreements, the parties agree to trade with one another, perhaps exclusively, *prior* to either party incurring seasonal start-up costs. These agreements typically have non-price compensation mechanisms such as financing of vessels by processors, and provision by processors of ancillary gear and services and/or the vessel itself.

The analysis tested the hypothesis that *ex ante* investments undertaken by some fishers result in a "temporal specificity"[2] problem; *reciprocal* specific investment costs are then incurred by some processors so as to credibly commit to the implicit contractual agreement. This reciprocal exposure is accomplished through *ex ante* processor investment specific to the harvesting operation.

2. TEMPORAL SPECIFICITY, HOLD-UP AND RECIPROCAL EXPOSURE IN THE INTERMEDIATE MARKET FOR RAW FISH

Upon entry into the B.C. fishing industry, participants in both the harvesting and processing sectors may choose among several different technologies. Entry into the harvesting sector requires a fisher to choose from among several technologies, h_i [h_1, . . . h_n], each characterized by some combination of input choices (i.e., vessel, gear-type, crew size, etc.), and each requiring different levels of fixed investment. Similarly, a fish buyer selects from among the alternative processing technologies, p_j [p_1, . . ., p_m] by incurring a fixed investment cost. Let I_F^i and I_b^j denote the amortized investments undertaken by a fisher investing in technology h_i and a buyer investing in technology p_j, respectively. Harvesting and processing investments are combined through a series of exchanges over several fishing seasons. The value of these combined initial investments is realized when the buyer sells the processed product to a final consumer. Not all configurations of harvesting/processing technologies are valuable. Let R^{ij} be the maximum expected gross (amortized) value of an exchange between a fisher choosing technology h_i and a processor choosing technology p_j.[3] If $R^{ij} \geq I_F^i + I_B^j$, efficiency considerations dictate that such an exchange should take place.

The extent to which harvesting and processing investments are relation-specific, depends upon the values of these investments in alternative exchanges. Let V_F^i denote the *ex post* opportunity cost of the fisher's investment. Any harvesting technology which results in $I_F^i > V_F^i$ is considered a *specific* investment; the greater is the difference ($I_F^i - V_F^i$), the higher is degree of specificity embodied in the harvesting operation.

The issue of temporal specificity arises here: the intermediate market for raw fish is characterized by time and space considerations that create significant quasi-rents ($R^{ij} - V_F^i - V_B^j$) between the fisher and the initial processor(s) approached to complete the exchange. This specificity is more pronounced the fewer are the number of alternative potential buyers, the more perishable is the catch and the more geographically dispersed are alternative buyers.

The size of V_F^i , and thus the severity of temporal specificity, is in turn affected by the nature of the fisher's *ex ante* choice of harvesting technology: the more inflexible is the technology, h_i, across fisheries or across species within a fishery, the lower is V_F^i; the more perishable is the intermediate product produced by h_i, the lower is V_F^i; harvesting technologies that restrict the processing techniques to which the intermediate product is suitable result in a lower *ex post* opportunity cost.

The *ex post* opportunity cost of a buyer's initial investment, V_B^j, varies across processing technologies. Those technologies which are inflexible across species and/or cannot be easily redeployed to non-fish products will have a lower expected value in an alternative use.

With such large quasi-rents, a fisher and a processor may be induced to engage in costly strategic behavior that renders "on the spot" contracting inefficient. Owing to the perishability of the intermediate product as well as the geographic dispersion of both buyers and sellers, these quasi-rents can be dissipated quite rapidly as each transactor attempts to capture a larger share.

There are some harvesting technologies that, although economically efficient, put the fisher at risk of hold-up: that is, "on the spot' negotiations are likely to result in a negative return for a fisher investing in technologies that lead to pronounced temporal specificity problems. Such a situation is depicted in Figure 1, where the length of the line segment, O_F0_B represents the gross revenue obtainable from a transaction between a particular fisher and buyer. The fisher and buyer incur ex ante (amortized) seasonal investment costs of 0_FI_F and 0_BI_B, respectively. Suppose ex post opportunity costs are given by 0_FV_F and 0_BV_B. An equal division of the quasirent at (N_F, N_B), which, for example, would obtain under ex post Nash bargaining, leaves the fisher with a negative return on his or her initial investment. Under these circumstances, the fisher is likely to recognize the potential for ex post hold-up and will be unwilling to incur the ex ante investment cost. This is identified as a market failure, since this transaction is *Pareto superior* to all alternative transactions.

This market failure can be corrected if, ex ante, the buyer undertakes a portion of the fisher's investment cost. For example, if the buyer takes over $G of the fisher's ex ante investment cost, the ex post division of the quasi-rent allows both parties to receive a positive return on their initial investments.

It is a combination of vessel and gear characteristics that determines the extent of *ex post* temporal specificity. Five gear-types are employed in the four fisheries under consideration (salmon, halibut, sablefish, herring): purse-seine, gillnet, troll, longline and trap.[4] First consider the flexibility of gear-type across species. The purse-seine and gillnet gear-types are employed in both the salmon and herring fisheries, but the nets are specific to each fishery - i.e., neither salmon purse-seine or gillnet gear can be used to harvest herring, and vice versa. These gear-types are most efficiently used to harvest schooling species of fish, which includes three species of salmon (chum, sockeye and pink) and all herring. Troll gear is employed only in the salmon fishery and is primarily used to target the non-schooling species (coho and chinook). Many salmon harvesting operations employ a combination of gillnet and troll gear, allowing them to efficiently harvest all species of salmon. Longline gear may be interchangeably employed in both the halibut and sablefish fisheries, while trap gear is specific to sablefish. The above considerations imply that harvesting operations employing the combination gear-type are the most flexible across

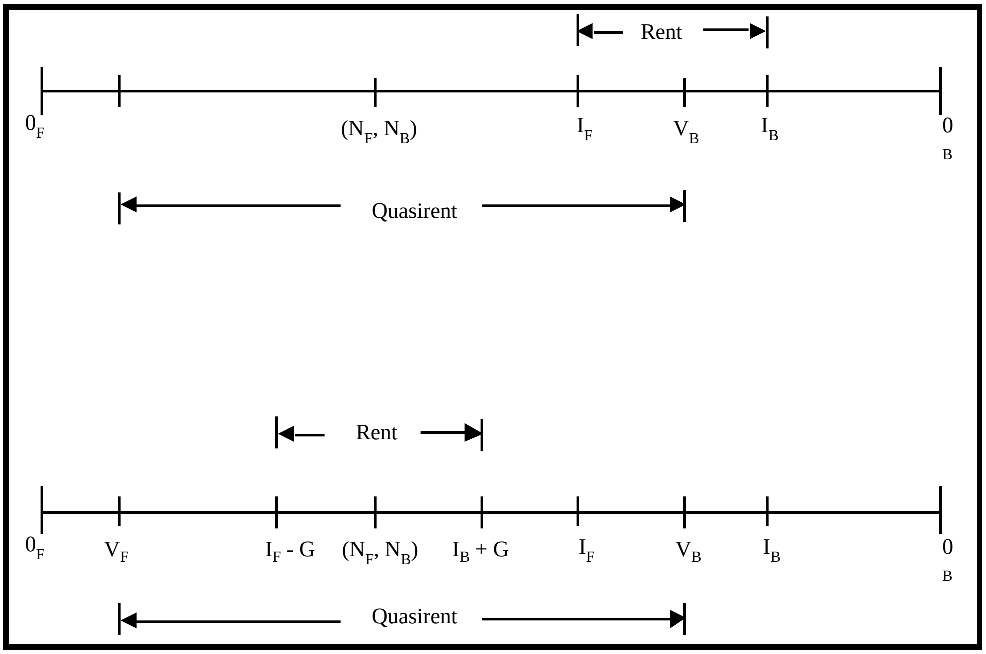

Figure 1

species; fishers employing these gear-types will, *ceteris paribus*, have more *ex post* exchange alternatives than fishers employing less flexible gear-types.

Consider next the impact, if any, of each harvesting technology on the perishability of the intermediate product. Perishability is partially determined by the nature of the species themselves: salmon and herring are naturally more perishable than sablefish and halibut. The more perishable is a vessel-load of fish, the less time a fisher has to find a buyer, and thus the fewer are the exchange alternatives. Smaller harvesting operations are able to extend the time between catch and delivery by conducting on-board dressing (gutting and heading) and freezing. The nature of the purse-seine technologies is such that very large volumes of fish are harvested per period, making it difficult to engage in on-board processing. They are thus restricted to delivering fish "in the round".[5] Fishers employing any of the other harvesting technologies have the option of delivering fish in the round, dressed, or frozen.[6]

The market for harvested fish consists of licensed buyers with some combination of canning, brining, smoking and cold-storage facilities. Each harvesting operation produces an intermediate product that is suitable for one or more types of processing. Herring is valued primarily for its roe; in 1988[7], thirty-five buyers were licensed to produce roe herring through a brining process. The vast majority of salmon is directed toward either the canned, fresh, or frozen markets. There were 129 enterprises licensed to process salmon in 1988; of these 126 were licensed to operate cold storage facilities, while only 13 were licensed to operate a commercial salmon cannery. In addition to the relevant demand and cost conditions for processed fish, the choice of product-form is determined both by the species' natural suitability to a particular form of processing as well as the effect of the harvesting technique on the raw product. Net-caught salmon tends to be suitable for the canned market, partly due to the nature of the target species themselves[8], and also because the fish are frequently marked and bruised by the nets. This latter problem is less pronounced for gillnetters than for seiners. Thus, the *ex post* exchange alternatives available to salmon seiners are quite limited. Troll-caught salmon, halibut and sablefish may be sold to any buyer with cold-storage facilities, implying fishers using these techniques have many *ex post* opportunities. Ninety-seven establishments were licensed to process "other finfish", which includes sablefish and halibut. Halibut and sablefish final product-forms include fresh, frozen and smoked products.[9]

While it is difficult to determine a precise ranking of asset-specificity across harvesting technologies, the above discussion leads to the following qualitative comparisons. The annual investment undertaken by a purse-seiner is identified as the most transaction-specific. The investment cost is likely to be recovered only through transactions with relatively few potential buyers. The fact that these buyers are geographically dispersed, combined with the high perishability of the intermediate product, implies very few delivery alternatives for such a fisher. The possibility that processing capacities are binding *ex post* further limits the expected market for the fisher's harvest. Single-licensed vessels employing only sablefish traps rank next in the specificity ranking, followed by single-licensed vessels employing only gillnets. The above discussion implies that vessels equipped with only troll gear or with longline gear are more flexible than the aforementioned operations. Harvesting operations employing multiple licensed vessels with combination troll/gillnet gear are identified as having the least transaction-specific investment. This ranking across gear types is based on the combined considerations of: flexibility of the gear across species; the natural perishability of the species targeted by the gear-type; the degree of quality control the harvesting operation is able to exercise; and the size of the market for the target species.

Consider now the *ex post* opportunity cost of processing inputs. Investments in cold storage and freezing facilities are flexible across virtually all fish species and may also be employed in non-fish uses. The canning technology, however, requires inputs (production line, distilling equipment, etc.) that cannot be easily redeployed to process species or food products other than salmon (Pinkerton).[10] Thus, the annual investment cost in canning facilities is specific to transactions with salmon seiners and gillnetters. Can we identify a portion of a canner's investment as specific to a particular transaction? The processor has invested in a capacity associated with a given volume of fish and a portion of that investment can be attributed to the transaction under consideration; if that investment can be recovered in an alternative exchange, then no specific investment has been undertaken by the processor. There are over 1,000 seiners and gillnetters producing an intermediate product suitable for the canned market, implying that the canner has a very large number of *ex post* opportunities available. However, the seasonal variability in salmon runs results in excess processing capacity for those years in which salmon runs are low. At times, therefore, the processor may find that it is unable to recover its initial investment in an anticipated transaction through an alternative exchange. Nevertheless, the degree of specificity embodied in a processor's investment, if any, is likely to be low, relative to that associated with a salmon- or herring-seiner's harvesting investment.

3. EMPIRICAL METHODOLOGY

The empirical analysis in Koss (1999) examined contract variation across product and technological characteristics in both the harvesting and processing sectors. The hypothesis is supported if there exists a (significantly) positive relationship between the degree of temporal-specificity in transactions and the use of *ex ante* credible commitments from processors to fishers. In particular, the empirical analysis determines the nature of the following relationship:

$$Y_j = f\left(Z\left(\mathbf{X}_j\right)\right)$$

$$Z_j = \alpha + \beta \mathbf{X}_j$$

where Z is the propensity of the exchange to *ex post* hold-up. Although Z is unobservable, the available data indicates whether Z takes on high or low values. High values of Z increase the probability that the transaction is conducted under an incomplete, long-term contract. Assuming the chance of hold-up is a linear function of the vector of explanatory variables $\mathbf{X_j}$, the probit model provides a suitable means of estimating the slope and intercept parameters of the hypothesized relationship. The probability that relationship j is governed by the use of an *ex ante* credible commitment, Y_j, depends upon the propensity of transactions between the j*th* parties to *ex post* hold-up, Z_j, which is in turn dependent upon the degree of temporal specificity that characterizes relationship j.

The fisher-processor relationship, *j*, is identified as being governed by the use of credible commitments if at least one of the following criteria are met[11]: 1. the vessel is fully or partially owned by the processor; or 2. the vessel is financed by the processor. The vector of explanatory variables, $\mathbf{X}_i$, as defined in Table 1, is intended to capture the "degree of temporal specificity" characterizing the fisher-processor relationship. The variable CAN accounts for the presence of a transaction-specificity in the processing technology. For those transactions where CAN = 1, we expect the processor to have a greater incentive to ensure deliveries are forthcoming by credibly committing to an exchange, and thus expect a positive estimated coefficient for this variable. The remaining variables (SEINE, . . . LONG) serve as proxies for capturing the degree of temporal-specificity embodied in the harvesting technology. These are five gear-type dummy variables with the base category represented by "combination gillnet/troll gear". Positive coefficients for each of the variables SEINE, GILL , TROLL, TRAP and LONG are expected, as the previous discussion indicates that an investment in combination gear is less specific than investments in any of these gear-types.

In order to determine the way in which the observed incidence of vertical ties vary across the explanatory attributes of the relationship, a stratified random sample[12] was generated from 1988 data in British Columbia. The sample consists of 1,830 vertical relationships between 726 vessels and 75 buyers. For each of the vessels, the identity of the owner(s) and creditor(s) (if any) are known. The distribution of ownership shares across owners is also known; thus, each transaction can be characterized as belonging to one of the following categories: the processor had majority ownership in the vessel; the processor had minority ownership in the vessel or financed the vessel; or there were no observable vertical ties that characterized the relationship. The sample represents a cross-section of vessels and processors operating in at least one of the salmon, herring, halibut, and sablefish fisheries. As previously described, the attributes of the intermediate product vary both across and within these fisheries, as do the harvesting and processing technologies.

3.1 The Ordered Probit Model

The choice between the three contractual alternatives was modeled using an *ordered probit analysis*. Let Y = 2 if the processor had majority ownership in the vessel, Y = 1 if the processor had minority ownership in the vessel **or** financed the purchase of the vessel, and Y = 0 otherwise.

The results of the ordered probit analysis are summarized in Table 2. Note that positive coefficients in column 2 of Table 2 imply a decrease in the reliance on spot market transactions. With the exception of the estimated coefficient for GILL, the null hypothesis is rejected with at least 95% confidence. In order to interpret the results of the ordered probit analysis, the marginal effects are presented in columns 3 -5 of Table 2. Column 3 indicates the effect of a change in x_i on the probability that the transaction is completed without any observable reciprocal investment; column 4 summarizes the effect of a change in x_i on the probability that the processor had minority ownership or financed the vessel involved in the transaction; and Column 5 illustrates the effect of a change in x_i on the probability that the processor had majority ownership in the vessel. Both the signs and the relative magnitudes of the marginal effects are consistent with paper's hypothesis. Transactions with canners are 26% less likely to be conducted on the spot market than transactions with processors or buyers without canning facilities; and the probability that a vessel is minority-owned or financed by the processor increases by 16% if the processor operates a canning facility; similarly, the probability that a vessel is majority owned by the processor increases by 9% if the processor operates a canning facility.

The marginal effects for the gear-type dummy variables are interpreted relative to the base category, "combination gear". Thus, relative to a transaction in which combination gear is employed, the probability that Y = 0 decreases when any of the other gear-types are employed. Further, this effect is more pronounced for gear-types which have been identified as the most temporally-specific, seine gear and trap gear. Vessels employing seine gear and trap gear are more likely to require a credible commitment from a processor than are the other gear-types.

The foregoing empirical analysis indicates a strong correlation between the incidence of vertical ties and the degree of temporal specificity in transactions. This correlation supports the hypothesis that *ex ante* reciprocal investment serves as an endogenous enforcement mechanism to transactions that are potentially threatened by post-contractual opportunistic hold-up.

Table 1: Independent Variables

CAN	=	1	if the jth relationship involves a processor that has invested in canning facilities
	=	0	otherwise
SEINE	=	1	if the jth relationship employed either herring or salmon seine gear
	=	0	otherwise
GILL	=	1	if the jth relationship employed gillnet but not troll gear
	=	0	otherwise
TROLL	=	1	if the jth relationship employed troll gear but not gillnet gear
	=	0	otherwise
TRAP	=	1	if the jth relationship employed trap gear
	=	0	otherwise
LONG	=	1	if jth relationship employed longline gear
	=	0	otherwise

4. CONCLUSIONS AND IMPLICATIONS OF FISHERY MANAGEMENT POLICY

What implications does the above finding have for fishery management policies? In particular, if the goal of fishery management is to maximize the value of the fishery, then policy should not hinder the use of contractual tools that serve to accommodate or promote efficient transactions. The dilemma facing policy-makers, however, is that such tools often simultaneously lead to an increase in the concentration of market power among a small group of processors.

In order to prevent the accumulation of market power among a few processors, Canada's Davis Plan (1968) limits direct processor ownership of the salmon fleet to 12%. This limitation requires fishers and buyers to search for other, possibly more costly means of establishing vertical ties. It would be helpful for policy-makers to distinguish between contractual practices that are motivated by the pursuit of market power and contractual practices that serve to enhance economic efficiency by lowering transaction costs.

The objective of fishery management policy has primarily been to reduce harvesting effort in order to promote sustainable catches. Many of these policies impose constraints on fishers that render their harvesting investments more specific to a small group of processors. Oftentimes fishery regulations make the harvesting technology less flexible across fisheries or across species within a fishery and result in an intermediate product that is suitable to fewer processing techniques.

Open-access regulations generally take the form of restrictions on how, when and where fish may be caught, which fish and how many fish may be caught. Some of these open access regulations tend to reduce the flexibility of a harvesting operation across species and product form, possibly reducing the number of potential buyers available to a fisher. If vessels are restricted to employing only one kind of gear-type for example, they may lose access to particular species or sub-species. Seasonal restrictions for purposes of managing catch levels are likely to result in fishers investing in larger fishing capacities – larger loads of fish are more perishable, increasing the degree of temporal specificity. Area restrictions may result in an increased cost of timely access to some processors.

Findings from the investigations of limited entry programs are that fishers readily find means of increasing fishing capital and power in order to capture the increased rents that become available. Fishery managers responded by first restricting vessel tonnage, then vessel length. Bans were then imposed on splitting licenses, combining licenses, transferring to different gear types, etc. (Wilen, 2000). Thus, many regulations that accompany limited entry programs have also tended to reduce the ex post exchange alternatives available to fishers.

The foregoing empirical findings suggest that, in order to avoid the increased potential for ex post hold-up, a rational and efficient response to the introduction of such restrictions is the reciprocal investment by processors in vertical ties with the harvesting operation.

Individual transferable quotas have emerged as the economists' favored solution to the over-fishing problem. Under this regime, fishers' incentives for 'capital stuffing' disappear, as does the need for a myriad of restrictions on the flexibility of the harvesting technology. It has also become apparent that ITQ programs provide fishers with an incentive to produce raw products that would sell in higher valued markets (Wilen, 2000). These implications and findings suggest that, under a system of ITQs, fisher and processors will reduce their dependence on long-term exclusive contracts accompanied by reciprocal investments.

This discussion suggests that vertical ties between fishers and processors are more likely to exist under regimes of open access regulations and limited entry programs, relative to regimes governed by ITQs. Since vertical ties, in and of themselves, are not necessarily undesirable, this should not be interpreted as yet another advantage of ITQs over open access or limited entry regimes. This conclusion does offer insight to policy makers who may be concerned about the motivation of contractual arrangements. Policies which restrict harvesting and processing technologies to exchanges with only a few parties can be anticipated to induce contractual behavior which appears to be anti-competitive. To the extent that vertical ties lead to enhanced market power of a small group of processors, however, ITQs are to be preferred over open access and limited entry regimes.

Table 2: Estimated Coefficients and Marginal Effects[13] of the Ordered Probit Regression

Variables	Coefficient	$\frac{f(\Pr ob(y=0)}{fx_i}$	$\frac{f(\Pr ob(y=1)}{fx_i}$	$\frac{f(\Pr ob(y=2)}{fx_i}$
CONSTANT	-1.14			
	(-21.70)			

CAN	0.714	-0.26	0.04	0.22
	(14.17; 301.78)[14]			
SEINE	1.45	-0.50	0.06	0.44
	(25.62; 379.59)			
GILL	0.11	-0.04	0.01	0.04
	(1.31; .207)			
TROLL	0.17	-0.06	0.01	0.05
	(2.07; 2.70)			
TRAP	1.48	-0.40	-0.13	0.53
	(13.29; 35.23)			
LONG	0.43	-0.15	0.01	0.14
	(5.29; 2.62)			
μ	1.02			
	(35.11)[15]			
Pseudo-R^2	0.62[16]			

* The pseudo-R^2 is the likelihood ratio index, $\rho^2 = 1 - \frac{L(\hat{\beta})}{L(\hat{\beta}^H)}$, where $L(\hat{\beta})$ is the log-likelihood of the unconstrained model and $L(\hat{\beta}^H)$ is the log likelihood of the model defined by the null hypothesis.

1 This type of arrangement corresponds to Williamson's "discrete transactions" paradigm (Williamson, 1975).

2 This term is introduced by Masten, Meehan and Snyder (1991). Temporal specificity has also been investigated in the bulk shipping market by Pirrong (1993).

3 It is assumed here that Rij is greater for this pair of processor-harvester than for any other. That is, fisher i and processor j are the optimal match from among all transactors.

4 Purse-seine vessels set a large net around schools of fish and then close off the bottom of the net with a purse-line; operation of this gear requires several crew members, a large motorized vessel, a power block to hoist the net, and a power drum to roll the net. The gillnet method entails the stringing of a net from behind a boat across a river, inlet, or passage in order to entangle and drown salmon on their spawning migration; this technique requires a relatively small vessel, a single-handed crew, a motor, net drum and nylon nets. Troll fishing is conducted by attaching fishing lures to lines extending from poles on the vessel, which are then towed behind the vessel at various depths; the size of the crew varies across vessels, but is generally smaller than that of a purse-seine vessel and larger than that of a gillnetter. Halibut and sablefish are harvested by the longlining method, whereby a long, set line, to which are attached regularly spaced short lines and baited hooks, is lowered to the sea bottom. The use of trap gear involves baiting large conical traps and attaching them to ground-line gear, which are then set on the sea bed (Department of Fisheries and Oceans, Vancouver, B.C.).

5 Fish delivered in the round are not gutted or headed, nor are they frozen on board.

6 Many seiners have invested in a "champagne cooling system", a large tank holding slushed ice, which does

serve to protect the catch for longer periods. However, virtually all trollers, combination vessels, sablefish trappers and longliners are equipped with ice-packing and/or freezing facilities, enabling them to preserve their catches for longer periods and at a higher quality than seiners (Shaffer, 1979).

7 Data used in the empirical analysis are from the 1988 fishing season.

8 Pink salmon, for example, is marketed almost exclusively in canned form, owing both to the unattractive "hump" on its back and its high oil content. The flesh of the chum species deteriorated rapidly when it enters fresh water, making it more suitable for the canned market if caught in fresh water. Sockeye salmon is also suited to the canned market as a result of its high oil content, but is also valued in fresh or frozen form (Shaffer, 1979).

9 Fisheries Production Statistics of British Columbia, 1988, Ministry of Agriculture and Fisheries.

10 The same is true for the investment in the brining inputs required to produce roe herring , although the size of the investment is lower than for canning inputs.

11 It is important to note that other types of vertical ties (e.g., processor-provision of moorage, storage space, vessel maintenance) are also indicative of the use of credible commitments. Unfortunately, information on these variables is unavailable.

12 Observations have not been drawn at random from the population, but are randomly drawn within particular strata. That is, the data are deliberately sampled so that both spot-market and each type of long-term contract transaction is adequately represented in the sample. Since, for example, processor-owned vessels constitute only 12% of all vessels in the population, a random sampling technique would result in a very few number of observations exhibiting this characteristic. Thus, of the 726 vessels in the sample, 50% meet one of the above criteria for a long-term contract, while the other 50% do not. Within each strata, however, the vessels used in the sample were selected randomly.

13 The marginal effects of the each of the binary variables have been computed by comparing the probabilities that result when the variable takes its two different values with those that occur with the other variables held at their sample means (Greene, 1997).

14 Bracketed values denote (t-ratio; LR test of significance). Under both the t-test and the LR test, the variables CAN, SEINE, and TRAP are significant at at least the 1% level of significance. The variables TROLL and LL are significant at 5% level under the t-test, but at slightly less than the 10% level under the LR test. The variable GILL is insignificant under both tests.

15 Here, the bracketed value is the t-ratio.

16 Judge et. al., 1985: 767.

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