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CONTRACTUAL CHOICE IN THE BRITISH COLUMBIA INTERMEDIATE MARKET FOR RAW FISH

by

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Contractual Choice in the British Columbia Intermediate

Market for Raw Fish

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ABSTRACT

The purpose of this thesis is to provide an economic rationale for observed contractual arrangements in the intermediate market for raw fish. Two general types of contracts have been observed: spot-market "contracts" and incomplete long-term contracts. The latter are typically accompanied by non-price compensation mechanisms, such as processor-provision of the vessel, ancillary gear, and credit. The contractual arrangement is observed to vary both across and within different fisheries.

The following hypothesis is proposed to explain this variation in contractual arrangements:

Owing to the presence of transaction-specific investments, there is potential for *ex post* **hold-up. The non-price compensation mechanisms that accompany long-term, incomplete contracts serve as credible committments to mutually advantageous exchange. That is, reciprocal** *ex ante* **specific investments are incurred in order to reduce the probability of** *ex post* **hold-up.**

The implication of this hypothesis is as follows:

The probability that a transaction will be governed by a long-term, incomplete contract rather than a spot-market transaction is directly correlated with the expected loss from potential *ex post* **hold-up.**

A simple model is developed in which a long-term, incomplete contract accompanied by non-price compensation is shown to promote efficient exchange. In

order to determine whether the above hypothesis is empirically supported, the following variables are identified as affecting the expected loss from potential hold-up:

1. perishability of raw fish

2. alternative sources of supply

3. alternative markets for the intermediate product

4. specificity of the harvesting technology to a particular species and/or to a particular intermediate/final product-form

5. specificity of the processing technology to a particular species and/or intermediate product-form

6. volume exchanged per delivery

A sample of over 15,000 transactions between fishers and processors is analyzed. Both non-parametric and parametric tests are conducted in order to examine the validity of the above hypothesis. The non-parametric chi-square test of independence offers support for each of the above variables as an important determinant of contractual choice. Similarly, both a binary probit and an ordered probit regression identify each of the above variables as significant determinants of contractual choice.

ACKNOWLEDGEMENTS

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CHAPTER ONE: INTRODUCTION

The market for raw fish serves as an interesting arena in which to study observed contractual arrangements for the transaction of an intermediate good. In British Columbia the nature of the contractual relationship existing between buyers and sellers of raw, unprocessed fish varies both across and within particular fisheries. The ultimate purpose of this study is to provide an economic rationale for these observed contractual arrangements.

Contractual arrangements in the British Columbia market for raw fish are observed to be of two general types:

1. A spot-market arrangement, wherein both buyers and sellers of raw fish seek exchange opportunities with one another after incurring the requisite seasonal investments (e.g., vessel maintenance, crew, processing facilities, etc.). There is no prior agreement for exchange to take place between the two parties, nor is there an agreement that the relationship will continue beyond a particular transaction. This type of arrangement corresponds to Williamson's (1975) "discrete transactions" paradigm.

2. A long-term, incomplete contract[1] in which parties agree to trade with one another, perhaps exclusively, prior to either party incurring seasonal start-up costs. The contract is incomplete in that the terms of trade are not completely specified in advance. Long-term contracts are generally observed to be accompanied by "non-price compensation mechanisms" such as season-end "bonuses" paid by processors to vessel owner/operators, the financing of vessels by processors, and the provision by processors of accounting and banking services to fishers.

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[1]Note that the term "contract" here refers simply to the rules that govern the relationship. These rules may or may not be explicitly defined. The majority of long-term contractual arrangements between processors and fishers appear to be implicitly rather than explicitly defined, presumably owing to the difficulty of contractually specifying in advance responses to all future contingencies.

The purpose of this thesis is to provide an economic rationale for the observed contractual variation in the B.C. intermediate market for raw fish. Two main bodies of literature potentially contribute to an understanding of how transactions for an intermediate product are completed. One posits that the choice of contractual arrangement is motivated by the pursuit or maintenance of market power. A second set of literature focuses on transaction costs as the key to explaining contractual behaviour.

The first set of literature includes both studies that have been directly applied to the fishing industry, as well as more general research. Three independent studies are of particular importance. Explanations for the use of non-price compensation mechanisms in raw fish transactions have been offered by Shaffer (1979), Schwindt (1982), and Pinkerton (1987). They have individually argued that it is the market structure of the processing sector that explains the reliance of some parties on "non-price competition" for raw fish supplies. They assert that the oligopsonistic nature of the market for raw salmon leads processors to explicitly or implicitly collude in order to keep the price of raw fish lower than would be possible if the buyers' side of the market was more competitive. When processors offer a higher price for raw fish in order to attract supply, competition for the limited supply will induce other firms in the industry to do the same. As the price of raw fish rises, processors' profits are eroded. Thus, such behaviour is viewed as "destructive" price competition. Each of the above authors maintains that changes in the level of non-price compensation are more difficult to detect than changes in the per unit price of fish; thus, non-price competition is the preferred method of acquiring supply.

With respect to the transaction-cost literature, two approaches are considered. One rationale often put forth to explain contractual complexities of the type described above is that of risk allocation (Borch, 1963; Arrow, 1970, 1975). Specifically the use of non-price compensation in long-term contracts may serve as a method of reducing the variation in suppliers' and/or buyers' incomes across states of nature.

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The explanation adopted by this paper stems from the transaction cost framework of Coase (1960), Klein et. al. (1978), and Williamson (1979). Owing to the difficulty and costliness of contractually specifying, monitoring, and enforcing all elements of performance for all possible contingencies, the transacting parties resort to an incomplete contract. When a contract is incomplete, however, there may exist a tendency for transactors to take advantage of the unspecified elements of contractual performance by opportunistic breach of the contractual understanding. In order to prevent contractual breach, the parties employ an "implicit" contract enforcement mechanism; that is, performance is implicitly enforced by the threat of termination (Klein, 1985). Under some circumstances, the threat of termination, by itself, is insufficient to prevent breach. The parties may then take other measures to ensure that the contract is self-enforcing.

The hypothesis offered in this paper is as follows: the non-price compensation mechanisms that accompany long-term contracts in the intermediate market for raw fish represent specific investments that serve as credible commitments to the contractual agreement.

Consider a transaction, T, in which *ex ante* investments by two parties (fisher and wholesaler) at one point in time are necessary. There is then a subsequent exchange in which the fisher sells fish to the wholesaler. Suppose further that these investments are, to some degree, transaction-specific. That is, the value of these assets in an alternative *ex post* exchange is less than their value in the transaction, T. Suppose that expected revenue from the transaction, T, exceeds costs (including opportunity costs), so that there are rents to the transaction. Efficiency then demands that transaction T occurs so that the rent is realized. By extension, we have market failure if transaction T is not undertaken.

In the absence of specificity, the investments will be undertaken and the potential rent realized, just as efficiency dictates. The presence of *ex ante* specific investment,

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however, potentially leads to *ex post* hold-up. If one party incurs *ex ante* specific investment costs that are in excess of the *ex post* opportunity cost of these assets, he/she potentially becomes the victim of hold-up. The opportunistic party may actually impose a loss on the other party, causing the latter to regret having made the *ex ante* specific investment.

Of course, a party will actually undertake an *ex ante* specific investment only if the expected net return from doing so is positive. The larger is a party's specific investment, the weaker is its bargaining position in the *ex post* game when fish are exchanged. Clearly, this deterioration in bargaining power can be so severe that the victim of hold-up may have regrets about incurring the specific investment in the first place. Assuming that the hold-up is anticipated and is sufficiently severe, the potential victim of hold-up will not undertake the initial investment. Market failure, driven by specificity of investments, then results.

An *ex ante* credible commitment to the exchange, undertaken by the potentially opportunistic party, may promote efficient exchange. *Ex ante* non-price compensation (e.g., vessel financing, provision of gear) from a wholesaler to a fisher serves as a credible commitment to an efficient transaction. Under some circumstances, such a commitment by the wholesaler is necessary to entice the fisher to participate in the transaction.

The implication of the above hypothesis is: the greater the expected loss from potential hold-up, the more likely it is that a long-term contract, accompanied by credible investments, will be observed.

It is possible to identify variables that are likely to influence the transacting parties' preferences for one contract over another. The preceding discussion suggests that the size of the loss a party expects to incur in the event of hold-up affects the individual's contractual choice. The extent of the potential loss to one party resulting from *ex post* opportunism by the other party is, in turn, dependent upon the degree to

which the initial investment is transaction-specific. Thus, those variables affecting the degree of asset-specificity also determine the preferred contractual arrangement.

The following variables, either directly or indirectly, augment the specificity of the initial investment. These variables are thus offered as determinants to the parties' preferences between a long-term, incomplete contract and a spot-market transaction: perishability of raw fish; volume exchanged per delivery; alternative sources of supply; alternative markets for the intermediate product; flexibility of the harvesting technology across species and across intermediate and final product-forms; and the flexibility of the processing technology across species and across final product-form.

The goal of the empirical work is to establish a connection between contractual choice and the presence of transaction-specific assets. In order to empirically test the validity of the above hypothesis, individual transactions between fishers and wholesalers are analyzed. Much of the data presented and used in the analysis constitutes a major contribution of this thesis. Both nonparametric and parametric tests have been conducted in order to explore the validity of the thesis' hypothesis. The nonparametric tests used in this analysis is the chi-square test of independence. The parametric test involves deriving the maximum-likelihood estimates of both a binary probit model and an ordered probit model.

Chapter 2 reviews the history of the British Columbia fishing industry and also describes the current state of the industry. A description of the intermediate market for raw fish is supplied in Chapter 3. The nature of transactions between fishers and processors is described for the two main types of arrangements: spot-market transactions and incomplete long-term contracts. Further, empirical regularities across a cross-section of fisheries, gear-types, and final product-forms are presented. Chapter 4 reviews the

relevant literature concerned with explaining contractual structure in vertical relationships. Two main motivations for contractual structure are explored: market-power incentives and transaction cost incentives. The hypothesis that contractual terms are designed so as to circumvent the hold-up problem is proposed. Chapter 5 presents an abstract and general model in which production of an intermediate product requires *ex ante* transaction-specific investments. In this model, *ex ante* credible commitments are shown to promote efficient exchange. Chapter 5 also discusses the application of the model to the B.C. intermediate market for raw fish. The empirical methodology and the results of the empirical analyses are provided in Chapter 6. Conclusions and possibilities for future research are presented in Chapter 7.

CHAPTER TWO:

HISTORY AND CURRENT STATE OF THE BRITISH COLUMBIA FISHING INDUSTRY

A. History of the Fish Harvesting and Fish Processing Sectors

1. History of the Commercial Fish Harvesting Sector

Prior to the arrival of European settlers on the Pacific coast of North America, salmon served as a dietary staple and as an exchange commodity for the indigenous coastal population. Sun-dried, smoked, and salt-cured salmon were consumed domestically and, subsequent to the arrival of European settlers, exported to the Hawaiian Islands and some Asian countries. The commercial canning of Pacific salmon began in 1864 in California as a response to a strengthening market for tinned salmon in the United Kingdom. The first cannery in B.C. was opened in 1870 near New Westminster (Childerhose and Trim, 1979). The commercial potential of halibut was recognized by the late 1800s. The New England Fish Company from Boston entered the Pacific halibut fishery in 1894 by establishing its headquarters in Vancouver and chartering two steamers (McMullan, 1987: 39).

In addition to salmon and halibut, the herring and groundfish fisheries have been important in the growth of the B.C. fishing industry. Before the turn of the century, herring was harvested in large volumes. It was used as halibut bait and served the dry salted market in the Orient. Fears of resource depletion led to the closure of the herring fishery in 1967. The roe herring fishery began in 1972 and continues to be a valuable fishery (McMullan, 1987: 42).

Prior to World War I, the groundfish fishery, which includes sablefish (black cod), sole, grey cod, and rockfish, was limited by a small local market demand. Heavy investment in shore

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processing facilities in the 1960s provided an intermediate market that was able to support a considerable fleet of groundfish trawlers.[1] However, markets for Pacific groundfish were, and continue to be, limited by competing supplies from other countries (McMullan, 1987: 43).

In addition to the fisheries described above, there exist numerous small fisheries in B.C. These include dive fisheries for abalone, geoduck, sea urchins and sea cucumbers. There also exist fisheries for shrimp, crab and clams.

Salmon continues to be the commercially most important fishery in B.C. Throughout the 1980s, the value of salmon landings constituted, on average, over 75% of all fish production in B.C. The value of roe herring landings varied between 15% and 35% of total fish production in the 1980s, rendering it the second most valuable fish species. Although halibut comprised one-fifth of total landings in 1970, it now represents only 1-2% of the wholesale value of all B.C. fish products.[2] The reduction in the relative importance of the halibut fishery stems partially from the development of new fisheries in B.C. and from excessive fishing in earlier years.

Regulatory History

The ownership of and jurisdiction over the Pacific fishery resources is divided between the federal and provincial governments. The conservation and management of fish resources entail two fundamental responsibilities: the preservation of fish habitat and controlling the harvest in order to conserve stocks (Pearse, 1982:37). The federal government retains constitutional jurisdiction over sea coast and inland fisheries. This authority extends from enacting legislation intended to protect fish habitat to the regulation of fishing activities. The *Fisheries Act (Canada)* provides general authority to regulate both marine and freshwater fisheries to ensure that the primary conservation mandate is met. The act and its regulations also establish a regulatory scheme designed to ensure orderly industry practice in tidal waters, licensing both individuals and vessels, and stipulating methods of fishing (Blewitt and Huestis, 1988). The provincial

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[1] The trawling method of fishing involves a vessel towing a net set very close to the sea-bed.
[2] Annual Statistical Review, Department of Fisheries and Oceans, 1980-1989.

government owns most of the uplands and the freshwater that serve as fish habitat. It has legislative authority over municipal affairs and most other upland activities that threaten fish habitat (Pearse, 1982:23). This constitutional division of authority between the two governments often leads to conflicting interests and responsibilities. Under the present system, the federal government retains law-making power and delegates to the province the authority for administering the legislation (Pearse, 1982: 33).

The need to control the expansion of fishing fleets in Canada's Pacific fisheries has been recognized for over a century. In 1889 the federal government limited the number of licences for fishing boats on the Fraser River to 500. The majority of these were distributed among canneries according to their canning capacity. As the canneries expanded in capacity, however, they became eligible for more licences. Moreover, additional licences were allocated to new canneries that were built. Consequently, this initial licensing scheme became ineffective in controlling the level of fishing effort applied to salmon stocks and was abandoned in 1892 (Pearse, 1982: 78).

A second experiment was attempted on the north coast, where the vast majority of the fleet was owned by canneries. In 1908 the Commissioner of Fisheries for B.C. placed a limit on the number of boats existing canneries were permitted to operate. The canneries negotiated privately among themselves in order to determine the allocation of vessels. As the value of the salmon escalated during World War I, the government acceded to the pressure to issue licences to new canneries. All restrictions on cannery licences were eliminated in 1917 (Pearse, 1982:78).

In 1968 the Davis Plan was implemented. The intent of this program was to control the salmon fleet through a system of restrictive licensing of vessels. The first phase of the scheme involved freezing the number of vessels by licensing only those showing significant dependence on the salmon fishery. A "buy-back" program was then implemented in which "excess" vessels were purchased by the government and retired (Pearse, 1982: 79).

As a result of the restrictive licensing program, the salmon fleet is smaller but the capacity of the fleet has increased. This is because the remaining vessels invested in additional fishing

power as the value of the catch increased (Pearse, 1982:79). Despite the lack of success in the B.C. salmon fishery, a restrictive licensing system is now in place for most of the other Pacific fisheries. Upon the introduction of a restricted entry regime, vessels or individuals have been allocated licences on the basis of historical catch. In the post-allocation period of a limited-entry fishery, potential entrants must either purchase, lease or inherit a licence from incumbent licence-holders. Both open-access and limited-entry fisheries are generally subject to the imposition of a "total allowable catch". Fisheries managers and biologists determine the maximum amount of fish that can be harvested while maintaining the viability of the fishery. The fishing season is closed for a fishery once the total allowable catch has been harvested.

In order to deal with the problem of continued investment in excess capacity on the part of licensed vessels, the Department of Fisheries and Oceans has introduced the "individual quota" system in some fisheries. Under this regime, a catch ceiling is imposed on each of the licensed vessels. A vessel quota, if monitored and enforced, attenuates the incentives of fishers to increase capacity; rather, fishers are encouraged to harvest their quotas at minimum cost. The individual quota system is currently used to manage a few of the dive fisheries and has very recently (1990) been implemented in the halibut and sablefish fisheries.

2. History of the Processing Sector

The commercial fishery in British Columbia was initiated by canneries. In the early years, the B.C. fish processing industry primarily served a large market for canned sockeye salmon in Great Britain. The B.C. canning industry developed in the 1870s along the Fraser River (Muszynski, 1987:48).

Until the 1890s the processing sector consisted of 10-15 small firms, all of which were either proprietorships or partnerships, and each of which received approximately equal market shares. Canneries acquired the labour force necessary for the harvesting and processing of salmon through offers of daily wages and family employment. Men fished from river banks or from

coastal, company-owned vessels, while women and children were employed in the canneries themselves (Marchak, 1987:23).[3]

In order to reduce their dependence on processors some fishermen began to form fishers' cooperatives in the late 1920s and 1930s. The cooperatives chartered, and later purchased, fish packers and sold fish directly to American buyers (Muszynski, 1987:58).

Local commission merchants with trade connections to Great Britain provided fish processors with financial capital, and supplied them with canning and harvesting resources as well as a distribution system to the market (Stacey, 1982:6). Until the 1870s the canners were dependent upon these externally provided distribution channels to consumer markets. Shareholders with trade connections to Great Britain obtained financial control of the processed product. The move of Canadian banks to British Columbia offered canners an alternative source of financial capital. By the early 1900s, canneries themselves began to incorporate, thus eliminating their financial dependence of distribution agents (Muszynski, 1987:48).

Overexpansion along both the Columbia and Fraser rivers led processing companies to seek alternative sources of raw fish supplies from Alaska and northern B.C. By the mid-1880s, salmon canning was the leading industry in B.C. in terms of both employment and value of exports.[4]

Processing firms began to merge with one another in the late 1890s. Acquisition of additional operations became attractive to canners after the federal government's introduction of a boat licensing program in 1889 (Marchak, 1987:23). Vessel licences along the Fraser River were limited to 500; those distributed to canning companies were based on capacity. Thus, by acquiring additional processing capacity a canner was also able to obtain greater harvesting capacity. By 1891 three large firms - Anglo-B.C. Packing Co. Ltd., Ewen & Co. and the Victoria Canning Co. Ltd. - controlled over 70% of the Fraser River sockeye salmon pack (Reid, 1975:282).

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[3]An additional source of labour was provided by Chinese immigrants who were brought in on contract to work in the canneries. The contractor typically supplied the entire cannery work-crew and was compensated by a piece-rate scheme (i.e., per case of packed salmon) Muszynski, 1987a:59).
[4]Forestry subsequently became the leading industry in B.C. by the late 1880s.

Four years after its introduction the boat-licence limitation program was abolished in response to considerable resistance on the part of both canners and fishers (Muszynski, 1987:50). This led to the entry of both fishers and processors. Thus the rise in industry concentration that arose during the first licence-limitation program was soon alleviated.

The B.C. Packers' Association of New Jersey, now known as B.C. Packers Ltd., was formally organized in 1902 with the amalgamation of a number of both small and large firms. The Canadian Fishing Company, originally a halibut fishing company, became the major rival of B.C. Packers in the early 1920s. The two companies have dominated salmon canning in British Columbia for most of this century (Muszynski, 1987:55).

Until the mid-1900s the processing sector of the B.C. fishing industry owned the vast majority of fishing vessels in the industry. Processing companies were thus able to control the level of effort applied to fish stocks, thereby preventing overharvesting. Vertical integration into the harvesting sector allowed processors to capture the majority of resource rent in the fishery.

After World War II an increased demand for fish products eventually encouraged the adoption of quick-freezing technologies in the processing of frozen fish. Processors also began to equip their fishing vessels and packers with refrigeration capacity. This meant that vessels were now able to transport fish over large distances, eliminating the need to establish processing facilities close to resource capture. The introduction of these technologies also resulted in the entry of small processors that could not meet the higher capital investment and labour costs required for canning (Muszynski, 1987:57). The number of independent operator-owned vessels also increased in response to the growing market demand for fresh/frozen fish. Despite these structural changes in the B.C. fishing industry, the processing sector continues to be dominated by a few large firms.[5]

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[5]See Tables 4-1 and 4-2 in Chapter 4.

B. Current State of the British Columbia Fishing Industry

More than 40 species of fish and marine mammals are now harvested and marketed by British Columbia's fishing and aquaculture industry. In 1991, commerical fishing licences provided 7,300 person-years of employment; the industry also supports an estimated 5,700 person-years in fish processing plants and shipyards.[6] In 1990, the total landed value[7] of fish was $479 million, while the wholesale value[8] was $947 million. This places the commercial fishery as the fourth largest primary industry in British Columbia, after forestry, mining and agriculture.[9] In terms of exports, fisheries constitute the fifth largest commodity group; in 1991, fish exports generated $635.2 million, which accounted for 4.2% of the value of all B.C. exports. Japan is currently the largest consumer of B.C. fish exports, followed closely by the United States. The provincial fishing industry produces only a small share of fish traded on the world market, and thus has little influence on prices.[10] In terms of its contribution to B.C. gross domestic product, the fishing and trapping industries combined account for less than 1% of GDP at factor cost in 1991.[11]

C. Description of Species and Harvesting Technologies

This research concentrates on four fisheries: salmon, halibut, herring and sablefish (black cod). The thesis posits that contractual choice for the exchange of raw fish hinges on the attributes of the harvesting and processing technologies, and the intermediate and final product-forms. Thus, these attributes require detailed attention.

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[6]British Columbia Economic and Statistical Review, 1991.
[7]"Landed value" refers to the value of raw fish landed at dock.
[8]"Wholesale value" refers to the value of fish wholly or partially processed, and raw fish sold through brokers.
[9]British Columbia Economic and Statistical Review, 1991.
[10]B.C. Economic and Statistical Reveiw, 1991.
[11]B.C. Economic and Statistical Reveiw, 1991.

1. Salmon

There exist five species of pacific salmon: sockeye, coho chinook (spring), chum and pink salmon. These species differ significantly in size, colour, oil content, taste, firmness of flesh, and tolerance to different forms of processing (Pinkerton, 1987:69). Common to each of the salmon species are the following characteristics: a short fishing season, high inter- and intra-seasonal fluctuations in supply, and the fact that Pacific salmon die after spawning (Shaw and Muir, 1987:5).

Salmon spawn in fresh water and spend their adult lives in salt water. The high inter-seasonal supply fluctuation results from the fact that adult salmon return to the spawning ground from which they originated after one to six years, depending on the species (Shaw and Muir, 1987: 2-5). Thus, the size of the spawning run in any particular year is dependent upon the size of the run in previous years. Pink salmon, for example, has a two-year spawning cycle. Thus, the size of a pink run in any particular year is determined by escapement[12] two years previously.

It is far more efficient for harvesters to target salmon when the fish are following their annual migratory spawning routes, rather than attempting to locate significant stocks in the open seas. Thus, the fishing season is naturally constrained by the spawning season. The majority of Pacific salmon spawn in the autumn, although a significant number spawn in late spring. Consequently, the salmon harvesting sector supplies large volumes of the raw product to fish buyers within a four month period (mid-July to mid-October). The propensity for large seasonal harvests is intensified by the fact that, for a given run, there is a strong incentive to harvest the entire surplus spawning population[13], since spawners not intercepted along their migratory paths are lost forever.

The salmon fishery employs three different harvesting technologies, the descriptions of which have been provided by McMullan (1987:35-38). Initially, B.C. canners harvested sockeye

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[12]Escapement refers to the number of spawners allowed to proceed upstream to spawn, rather than being harvested.
[13]The "surplus" refers to that portion of the spawning population that, if left unharvested, would not serve to augment the size of future salmon runs. Owing to the role of natural mortality in population dynamics, an increase in escapement beyond a certain level will not serve to increase the size of future runs.

salmon by use of the gillnet method of fishing. This method entails the stringing of a net from behind a boat across a river, an inlet, a passage, or a channel in order to entangle and drown salmon on their spawning migration. Gillnetting requires a relatively small vessel, a single-handed crew, a motor, net-drum and nylon nets.

In 1886 purse-seining was introduced to the west coast (Phillips, 1971:3C). A purse-seine vessel sets a large net around schools of fish and then closes 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 (McMullan, 1987:36-37). Many seiners have also invested in a "champagne cooling system", a large tank holding slushed ice, which serves to preserve the catch for a longer period

In the early years of its use, the nature of the purse-seine gear necessitated considerable manpower (usually 7 crew members plus the captain). This led to the introduction of a share system for dividing the value of the catch. Since 1941, this system has been based on 11 shares: 4 for the vessel and 7 for the crew, with payments for nets and the captain's share taken from the vessel's share. Technological innovations introduced in the 1950s, such as the power block and power drum, reduced the crew size to 4 or 5 persons (McMullan, 1987:36-37).

Troll fishing is conducted by attaching fishing lures to lines extending from poles on the vessel. These lines are then towed behind the vessel at various depths. All troll vessels are equipped with either ice-packing or freezing facilities. The size of the crew varies across troll vessels, but is generally smaller than that of a purse-seine vessel and larger than that of a gillnetter (McMullan, 1987:37-38).[14] Many salmon fishing vessels have been equipped with both gillnet and troll gear, and are referred to as "combination vessels".

Salmon enters the consumer market in one of the following forms: canned, fresh, frozen, smoked, and salt-cured, with the first three accounting for the majority of marketed salmon. In addition to the relevant demand and cost conditions for processed fish, the choice of product-

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[14]It is only recently that trollers began to employ deckhands. Technological advances of telecommunications and adaptation of their gear have led to increased competition with net fleets to capture sockeye, chum and pink salmon species. This, in turn, has led them to increase capacity by hiring additional crew members (McMullan, 1987: 38).

form is determined by the species' natural suitability to a particular form of processing as well as the effect of the harvesting technique on the raw product. Pink salmon, for example, is marketed almost exclusively in canned form, partially because of the unattractive "hump" on its back, and partially because of its high oil content. A unique feature of the chum species is that the flesh deteriorates 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 (Shaffer, 1979: 23-25).

Gillnet and seine vessels are capable of catching all species, but the net gear is most efficient in the harvest of sockeye, pink and chum since these species tend to run in schools. Net-caught salmon are generally more appropriate for the canned market. This is partly due to the nature of the target species themselves, and also because the product is frequently marked and bruised by the net. Troll vessels catch primarily coho and chinook salmon. Troll-caught salmon is, in general, better suited to the higher-valued fresh, frozen, smoked and salt-cured markets. Because they are equipped with ice-packing and/or freezing facilities, troll vessels are able to preserve their catches for a longer period and at a higher quality than gillnetters or trollers. Quality is a more important consideration to the fresh/frozen market than to the canned market. The non-destructive nature of troll gear also contributes to the fact that troll-caught fish receive a higher price per pound on the fresh/frozen market than do net-caught fish (Shaffer, 1979:23-27).

There were 3,691 commercial salmon fishing licences issued in 1988: 549 for seine vessels, 799 for troll vessels, 658 for gillnet vessels, and 2,229 for combination troll-gillnet vessels.[15]

Table 2-1 depicts the distribution of salmon landings across species and gear-type for the years 1984 - 1989. The proportion of salmon landings by species and gear for the same period is shown in Table 2-2. This information indicates that the purse-seine fleet catches the majority of

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[15]Annual Summary of British Columbia Commercial Catch Statistics, 1988, Department of Fisheries and Oceans, Pacific Region.

B.C. salmon and that pink salmon is the dominant species in terms of landed weight. The majority of gillnet catch consists of sockeye and chum; the majority of seine catch consists of pink and chum; troll gear is shown to target chinook and coho more consistently than the other species. Note also the high degree of interseasonal variation in catch. For example, total salmon catch more than doubled from 1984 to 1985, yet fell by 36% from 1986 to 1987.

2. Halibut

Unlike salmon, halibut is a long-lived demersal (bottom-dwelling) fish. Those not caught in one year may still be harvested in another. In the absence of regulatory constraints, halibut can be fished for a much longer season than salmon; fishers do not have to await the spawning season in order to locate harvestable stocks (Pinkerton, 1987:86).

Halibut is harvested by the long-lining method whereby a long, set line, to which are attached regularly spaced short lines and baited hooks, is lowered to the sea bottom. After a time, the captured halibut are hauled on board, gutted, cleaned and iced down. There is also a considerable volume of halibut taken incidentally in the salmon troll and gillnet fisheries, although retention of these catches is restricted. Because of its low oil content, halibut is not as perishable as salmon (Pinkerton, 1987:86). Its low perishability and low oil content contribute to the suitability of marketing halibut as a fresh or frozen product. The majority of halibut has been marketed in frozen form, primarily because, prior to 1990, a regulatory constraint on season-length resulted in highly concentrated deliveries of fish that required rapid processing.[16] Halibut landings for the years 1984 - 1989 are shown in Table 2-3. Note that, relative the salmon fishery, landings of halibut are relatively stable from year to year. Over this five-year period, for example, halibut landings remained between 4,000 and 6,000 tonnes.

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[16]The introduction of the individual quota system in 1990 led to the removal of the regulatory constraint on season-length.

Table 2-1: LANDINGS OF SALMON BY SPECIES AND GEAR, 1984-1989

(Round Weight in Tonnes)

SPECIES/ GEARTYPE	1984	1985	1986	1987	1988	1989
GILLNET	12,761	25,218	26,130	16,027	19,281	20,616
CHIN	763	525	516	271	485	789
SOCK	6,542	13,461	11,073	6,619	7,591	12,745
COHO	518	857	981	380	417	687
PINK	1,826	4,012	4,217	4,464	1,745	2,687
CHUM	2,988	6,211	9,216	4,236	8,966	3,955
SEINE	20,514	58,676	53,156	29,465	50,401	42,936
CHIN	444	733	580	355	298	557
SOCK	5,791	14,735	12,944	6,283	3,693	17,266
COHO	843	1,410	1,776	985	620	1,194
PINK	7,811	25,996	23,679	15,415	25,559	19,068
CHUM	5,603	15,769	14,152	6,413	20,218	4,846
TROLL	17,157	23,669	24,652	21,203	17,866	25,175
CHIN	5,047	4,211	3,911	4,623	5,138	3,889
SOCK	544	3,373	6,816	2,133	659	4,642
COHO	8,728	6,710	10,481	7,050	6,040	6,871
PINK	2,422	7,692	1,609	7,042	4,913	9,250
CHUM	412	1,666	1,829	351	1,113	521
TOTAL	50,431	107,563	103,938	66,695	87,548	88,727
CHIN	6,254	5,469	5,007	5,249	5,921	5,234
SOCK	12,877	31,569	30,833	15,035	11,943	34,383
COHO	10,089	8,977	13,238	8,415	7,077	8,752
PINK	12,058	3,770	29,505	26,921	32,217	31,004
CHUM	9,003	23,646	25,197	11,000	30,297	9,322

Source: Annual Summary of British Columbia Commercial Catch Statistics, 1989
        Department of Fisheries and Oceans, Pacific Region

Table 2-2 PROPORTION OF SALMON LANDINGS BY SPECIES AND GEAR, 1984-1989

(Round Weight in Tonnes)

SPECIES / GEARTYPE	1984	1985	1986	1987	1988	1989	AVERAGE
GILLNET	12,761	25,218	26,130	16,027	19,281	20,616	20,006
CHIN	0.06	0.02	0.02	0.02	0.03	0.04	0.03
SOCK	0.51	0.53	0.42	0.41	0.39	0.62	0.48
COHO	0.04	0.03	0.04	0.02	0.02	0.03	0.03
PINK	0.14	0.16	0.16	0.28	0.09	0.13	0.16
CHUM	0.23	0.25	0.35	0.26	0.47	0.19	0.29
SEINE	20,514	58,676	53,156	29,465	50,401	42,936	42,525
CHIN	0.02	0.01	0.01	0.01	0.01	0.01	0.01
SOCK	0.28	0.25	0.24	0.21	0.07	0.40	0.24
COHO	0.04	0.02	0.03	0.03	0.01	0.03	0.03
PINK	0.38	0.44	0.45	0.52	0.51	0.44	0.46
CHUM	0.27	0.27	0.27	0.22	0.40	0.11	0.26
TROLL	17,157	23,669	24,652	21,203	17,866	25,175	21,620
CHIN	0.29	0.18	0.16	0.22	0.29	0.15	0.22
SOCK	0.03	0.14	0.28	0.10	0.04	0.18	0.13
COHO	0.51	0.28	0.43	0.33	0.34	0.27	0.36
PINK	0.14	0.32	0.07	0.33	0.27	0.37	0.25
CHUM	0.02	0.07	0.07	0.02	0.06	0.02	0.04
TOTAL	50,431	107,563	103,938	66,695	87,548	88,727	84,150
GILLNET	0.25	0.23	0.25	0.24	0.22	0.23	0.24
SEINE	0.41	0.55	0.51	0.44	0.58	0.48	0.49
TROLL	0.34	0.22	0.24	0.32	0.20	0.28	0.27
CHIN	0.12	0.05	0.05	0.08	0.07	0.06	0.07
SOCK	0.26	0.29	0.30	0.23	0.14	0.39	0.27
COHO	0.20	0.08	0.13	0.13	0.08	0.10	0.12
PINK	0.24	0.04	0.28	0.40	0.37	0.35	0.28
CHUM	0.18	0.22	0.24	0.16	0.35	0.11	0.21

Source: Annual Summary of British Columbia Commercial Catch Statistics, 1989
        Department of Fisheries and Oceans, Pacific Region

3. Roe Herring

Like salmon, the size of the herring stock fluctuates annually. Herring about to spawn are captured either by the purse-seine method or by gillnets strung from small aluminum skiffs. Since the valued product is the mature herring roe, harvesting must take place when the roe is at its most mature pre-spawning stage (McMullan, 1987:42). Thus, even in the absence of regulatory closures, the herring roe fishing season is naturally very short (1-7 days). The high value of this product has encouraged the development of species-specific technology that has been used in conjunction with the traditional salmon fishing gear (Schwindt, 1982:90). In particular, recently constructed herring seiners have been adapted to carry immense volumes of fish (McMullan, 1987:43). A large holding capacity mitigates the need to make in-season deliveries to processors. This is a great advantage given the constraint of a very short herring fishing season.

Herring landings for the years 1984 - 1989 are shown in Table 2-3. Like salmon, the spawning cycle of herring is shown to result in large interseasonal fluctuations in harvest. In 1989, seine-caught herring accounted for approximately 56% of herring roe landings, while gillnetters accounted for 44% of landings.[17]

4. Sablefish

Sablefish, or black cod, is a groundfish with characteristics similar to halibut. The majority of sablefish is caught by the use of either longline or trap gear (Schwindt, 1982:118). The latter involves baiting large conical traps and attaching them to ground-line gear, which are then set on the sea-bed.[18] Since the introduction of the individual quota system in 1989, the sablefish fishery has become a year-round fishery. Prior to this it was subject to a seasonal closure once the total allowable catch had been harvested. Sablefish enters the final consumer market as a fresh, frozen, or a smoked product. Sablefish landings by gear-type for the years 1984 - 1989 are shown in

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[17]Annual Summary of British Columbia Commercial Catch Statistics, 1988, Department of Fisheries and Oceans, Pacific Region.
[18]Department of Fisheries and Oceans, Vancouver

Table 2-3. In 1989, approximately 70% of sablefish landings were caught by the use of trap gear, 18% by longline gear, and 12% by trawl gear.

Table 2-3: LANDINGS OF ROE HERRING, HALIBUT AND SABLEFISH, 1984-1989

(Tonnes)

	1984	1985	1986	1987	1988	1989
Roe Herring(1)	32,795	24,588	15,732	37,029	30,070	40,210
Halibut(2)	4,033	4,704	5,390	5,444	5,866	4,659
Sablefish(1)	3,852	4,263	4,686	4,717	5,291	5,495

(1) Tonnes, round weight
(2) Tonnes, dressed. head off weight

Source: Annual Summary of British Columbia Commercial Catch Statistics, 1989
        Department of Fisheries and Oceans, Pacific Region

D. Description of Final Product Forms and Processing Technologies

It is convenient to distinguish between two classes of raw fish buyers: processors (with cold storage and/or canning facilities); and "fish buyers". Fish processors and buyers are currently licensed under the authority of the *Fisheries Act*. The business of fish buying refers to the activity of *"buying, collecting, assembling, eviscerating, transporting, conveying, packing, or carrying fish."*

Fish buyers in British Columbia are generally distinguished as shore stations, packing vessels and trucks. Although some shore stations do minor processing, the fish are generally transported from shore stations to processing plants or distributors. Licensed packing vessels transport fish to shore stations or directly to a processor's plant. Truck buyers are mobile operators who purchase fish directly from fishers and transport it to market or to a wholesaler (processor, broker, or trading company) (Blewitt and Huestis, 1988:26-27).

The majority of licensed buyers have close affiliations to processors. Blewitt and Huestis (1988) estimate that over 80% of shore stations, over 60% of truck buyers, and the majority of licensed fish buying vessels are affiliated with established processing companies.

In 1988, the Ministry of Agriculture and Fisheries (MAF) issued 248 fish processing licences and 494 fish buying licences. Decals are issued along with the licence to specify the category of processing or buying which they may undertake. In 1988, there were 129 enterprises licensed to process salmon, 35 licensed to process roe herring, and 97 licensed to process other finfish. Thirteen establishments were licensed to operate a commercial salmon cannery and 126 cold storage facilities were issued processing licences. In addition, 96 operators were licensed to operate facilities that did not involve either cold storage or canning procedures. With respect to buying licences, MAF issued 294 salmon decals, 209 roe herring decals, and 116 finfish decals.[19]

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[19]Fisheries Production Statistics of British Columbia, 1988; Province of British Columbia, Ministry of Agriculture and Fisheries

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Shaw and Muir (1987) provide a detailed description of the main salmon product-forms and the associated processing procedures. When the raw product is destined for either the fresh or frozen markets, fish should be slaughtered quickly and cleanly. Fresh salmon involve very little, if any, processing: they are marketed whole or sold dressed (i.e., gutted and gilled). Ideally, they should be iced within one hour of slaughter and packed in insulated boxes. Frozen salmon are usually headed and dressed before being individually blast frozen for at least twelve hours, after which they are glazed and packed.

The above activities required for fresh and frozen salmon production are largely manual and, as noted, must be accomplished quickly after harvesting. Thus, in many cases, such activities are undertaken by fishermen themselves unless distances to processors are short.[20] In addition to on-board freezing and freezing undertaken at a processing plant, fish can also be frozen and stored in public cold stores on a contract basis.

In order to produce canned salmon, fish are first delivered whole to a processing plant located near landing points. The delivery itself is generally undertaken by tender vessels that are employed by canneries, rather than by the fishers themselves. In this way, more time can be allocated to the actual harvesting of fish. Upon delivery, the roe is extracted and processed separately. Specifically, the salmon roe is soaked in brine, packed in wooden boxes, and salted and cured at room temperature for several days prior to shipping. The salmon themselves are headed, gutted, cut into pieces, put into sealed cans, and cooked in a "retort" (a glass distilling container) prior to being boxed and shipped.

In the production of salt-cured salmon, fillets are salted and spiced or chilled in a brine solution. Both the smoking and salt-curing processes produce an end-product that is fairly perishable with a shelf-life similar to that of fresh iced fish. Preservation can be extended with the use of vacuum packs or controlled atmospheric packs.

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[20]This is primarily the case with troll-caught fish. The majority of gillnet operations, and all of the seine operations, involve quantities too large for the fishers to conduct on-board processing. Therefore, net-caught salmon is delivered primarily to shore-based processing plants or to tender vessels.

The production of fresh fish is less costly than that for either frozen or canned salmon. In fact, the preparation of a fresh product is often completely integrated with the harvesting operation or left to the final consumer. It is difficult to determine whether per unit processing costs are higher for canners or freezers. Although canners must incur the high fixed costs of acquiring production lines, the cost of storage is much lower than that for a frozen product. Another advantage of canning over freezing is the ability to carry over inventories from a high supply year to low supply years, owing to the much longer shelf-life of the canned product. The high concentration of deliveries to processors also favours a canning technology.[21] Within any particular season, the largest volume of salmon arrives within a three to six week period and, owing to its perishability, must be processed quickly. Pinkerton (1987: 69-70) maintains that large-scale canning is accomplished much more rapidly than large-scale freezing; firms that purchase large volumes of salmon during this time cannot freeze the majority of it quickly enough to avoid decomposition. Thus, although salmon attracts a higher consumer price when marketed in fresh/frozen form, there appear to be significant advantages with respect to storage and inventory carry-over in the production of a canned product.

Approximately one-half of canned salmon is consumed domestically. Canned salmon exports are primarily directed to European markets. The majority of frozen salmon is exported. B.C. competes with the United States for both the domestic frozen salmon market and for the Japanese and European markets (Schwindt, 1982:28).

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[21]A high concentration of deliveries to processors results from the fact that salmon is harvested during spawning migrations in summer and early autumn.

Table 2-4 depicts the distribution of salmon landings across final product-form by species.[22] Chinook, coho and chum salmon enter the wholesale market primarily as a frozen-dressed product, while the majority of sockeye and pink salmon are canned.

The distribution of salmon wholesale value across species, for the years 1984 - 1989, is depicted in Table 2-5. In general, sockeye salmon is dominant in terms of industry wholesale earnings, followed by pinks and chums. The chinook and coho varieties contribute approximately equal amounts to salmon wholesale revenues. Table 2-6 shows the distribution of total salmon wholesale earnings across product-forms for the years 1984 - 1988. The proportions of salmon wholesale earnings across these product-forms are indicated in Table 2-7. Canned and frozen salmon production constitutes the vast majority of salmon wholesale earnings. These final product-forms are relatively equal in terms of their contributions to salmon wholesale revenues.

Wild salmon (i.e., salmon that is not farmed) generated a total of 583.6 million dollars in wholesale revenues in 1988, constituting approximately 59% of total fish wholesale earnings in British Columbia. The export market dominates the salmon industry, accounting for 69% of salmon wholesale revenues.[23]

The markets for halibut are varied and variable. Exports as a proportion of total catch fluctuate annually. All exports of fresh halibut are destined for the United States, while there are many export markets for frozen halibut (Schwindt, 1982:113).

Halibut wholesale revenues for the years 1984 - 1988 are shown in Table 2-5. Halibut generated a total of 26.8 million dollars of wholesale revenue in 1988, accounting for 2.7% of total fish wholesale earnings in British Columbia. The halibut export market accounted for 65% of halibut wholesale earnings.[24]

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[22]Data is not available for the proportion of salmon landings directed toward an undressed final product or smoked and salt-cured production. This accounts for the fact that the distribution of landings across the product-forms do not sum to 1 in Table 4.
[23]Fish Product Exports of British Columbia, 1988; Department of Fisheries and Oceans.
[24]Fish Product Exports of British Columbia, 1988; Department of Fisheries and Oceans.

Table 2-4: DISTRIBUTION OF SALMON LANDINGS ACROSS FINAL PRODUCT-FORM

BY SPECIES, 1984-1988 (Round Weight in Tonnes)

SPECIES/ PRODUCT-FORM	1984	1985	1986	1987	1988	AVE
CHINOOK	6,254	5,458	5,007	5,249	5,921	5,580
CANNED	0.01	0.02	0.03	0.02	0.01	0.02
FRESH DRESSED	0.10	0.07	0.10	0.09	0.07	0.09
FROZEN DRESSED	0.64	0.64	0.60	0.63	0.67	0.64
SOCKEYE	12,877	31,569	30,833	15,055	11,943	20,451
CANNED	0.39	0.40	0.42	0.45	0.38	0.41
FRESH DRESSED	0.05	0.02	0.02	0.03	0.03	0.03
FROZEN DRESSED	0.28	0.29	0.29	0.32	0.32	0.30
COHO	10,089	8,577	13,238	8,415	7,077	9,559
CANNED	0.06	0.10	0.14	0.08	0.07	0.09
FRESH DRESSED	0.06	0.06	0.08	0.12	0.08	0.08
FROZEN DRESSED	0.72	0.63	0.52	0.67	0.62	0.63
PINK	12,059	37,700	29,505	26,121	32,217	27,680
CANNED	0.61	0.58	0.66	0.49	0.50	0.57
FRESH DRESSED	0.01	0.02	0.01	0.03	0.02	0.02
FROZEN DRESSED	0.14	0.16	0.06	0.20	0.14	0.14
CHUM	9,003	23,646	25,197	11,000	30,297	19,829
CANNED	0.17	0.34	0.23	0.12	0.15	0.20
FRESH DRESSED	0.03	0.01	0.05	0.05	0.05	0.05
FROZEN DRESSED	0.61	0.46	0.45	0.55	0.47	0.51
SALMON TOTAL	50,432	107,563	103,938	66,695	87,548	83,235
CANNED	0.29	0.38	0.39	0.33	0.29	0.34
FRESH DRESSED	0.05	0.02	0.04	0.06	0.04	0.04
FROZEN DRESSED	0.44	0.33	0.30	0.38	0.36	0.36

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

Table 2-5: WHOLESALE VALUE OF FISH BY SPECIES, 1984-1988

($'000)

SPECIES	1984	1985	1986	1987	1988
SALMON	276,241	512,243	536,223	425,603	583,630
CHINOOK	0.17	0.08	0.06	0.10	0.10
SOCKEYE	0.31	0.40	0.46	0.35	0.26
COHO	0.22	0.10	0.13	0.15	0.10
PINK	0.16	0.26	0.20	0.25	0.28
CHUM	0.13	0.15	0.15	0.13	0.25
ROE HERRING	96,058	100,115	85,454	170,132	171,860
HALIBUT	11,640	15,723	25,521	33,881	26,766
SABLEFISH			14,140	18,953	20,566

Source: Fisheries Production Statistics of British Columbia, 1988
Province of British Columbia, Ministry of Agriculture and Fisheries

The processing of herring roe is a simple, labour intensive procedure. After harvest, the raw fish are allowed to age in order to facilitate the extraction of roe, which is accomplished manually. The roe is then brined in stages, graded and packed for export (Schwindt. 1982:94). Japan alone provides the market for processed herring roe; moreover, 60% of Japanese consumption occurs during the New Year holiday (Schwindt, 1982:87). Thus, the harvest of herring takes place seven to eight months prior to final consumption.

Herring wholesale revenues for the years 1984 - 1988 are shown in Table 2-5. As indicated, the herring roe product-form constitutes the largest proportion of wholesale earnings

from B.C. herring. Herring generated a total of 175.5 million dollars in wholesale revenue in 1983, comprising 17.8% of total fish wholesale earnings in British Columbia. The export market accounted for 95% of herring wholesale revenues.[25]

Sablefish wholesale revenues are depicted in Table 2-5. Sablefish final product-forms include fresh, frozen and smoked products. Wholesale earnings from sablefish constituted only 2.1% of total fish wholesale earnings in B.C. in 1988, of which 99% was earned on the export market.[26]

Table 2-6: WHOLESALE VALUE OF SALMON BY PRODUCT-TYPE, 1984-1989

($'000)

	1984	1985	1986	1987	1988
SALMON	276,241	512,243	534,223	425,601	583,630
CANNED	94,457	258,646	277,913	171,573	236,780
FRESH	15,432	14,137	19,244	24,773	23,944
FROZEN	145,769	206,647	198,557	189,824	265,686
ROE	5,065	12,019	13,947	9,180	20,289
OTHER	15,608	20,794	26,562	30,251	36,931

Source: Fisheries Production Statistics of British Columbia, 1988
        Province of British Columbia, Ministry of Agriculture and Fisheries

[25]Fish Product Exports of British Columbia, 1988; Department of Fisheries and Oceans.
[26]Fish Product Exports of British Columbia, 1988; Department of Fisheries and Oceans.

Table 2-7: SHARE OF SALMON WHOLESALE VALUES BY PRODUCT-TYPE, 1984-1988

($'000)

	1984	1985	1986	1987	1988	AVE
SALMON	276,241	512,243	536,123	425,601	583,630	466,788
CANNED	0.34	0.50	0.52	0.40	0.41	0.43
FRESH	0.06	0.03	0.04	0.06	0.04	0.04
FROZEN	0.53	0.40	0.37	0.45	0.46	0.44
ROE	0.02	0.02	0.03	0.02	0.03	0.02
OTHER	0.06	0.04	0.05	0.07	0.06	0.06

Source: Fisheries Production Statistics of British Columbia. 1988
Province of British Columbia, Ministry of Agriculture and Fisheries

CHAPTER 3

DESCRIPTION OF THE INTERMEDIATE MARKET FOR RAW FISH

A. Contractual Arrangements in the Intermediate Market for Raw Fish

The trading arrangements existing between fish harvesters and fish purchasers varies both across and within fisheries. At one extreme are transactions in which the ownership of the fish harvesting and fish processing operations are integrated. In particular, the processor owns all of the inputs that are required to produce the final product, including the vessel and gear. At the other extreme are arms'-length transactions in which all harvesting inputs are owned by one entity and all processing inputs are owned by a different entity. Between these two extremes lie a myriad of contractual arrangements between the two parties. In some cases, there may exist partial integration in the sense that some harvesting inputs are supplied by the processor while others are supplied by the fisher. In other cases, the operations may be completely separable in terms of ownership, but the two parties may arrive at an exclusive dealing arrangement. Given such a multitude of arrangements between fishers and processors, it is difficult to discern a general process of price determination in this intermediate market. Indeed, price determination is complicated even for transactions taking place under a given contractual arrangement.

The price paid for raw fish is a derived price; that is, the price paid depends on the value of the end products and the costs of "processing". Processing entails three distinct activities: the collection of fish; conversion of the raw product into a final product (i.e., canning, freezing, smoking); and distribution of the processed product.

Fish end-products are differentiated by form (canned, fresh, frozen), market segment (domestic, export), and quality. This, in turn, results in differentiation in raw fish species according to delivered product-form (e.g., round, dressed head-on, dressed head-off, frozen); size (larger fish are typically worth more); area (quality of fish may vary across areas); and time of year (quality of some fish varies within the season).[1]

The above factors affect the flexibility that the buyer has in diverting raw fish to particular markets and the value of that fish in those markets. However, not all of these factors are necessarily reflected in prices paid to fishers; a significant amount of "averaging" or "blending" may take place. The averaging process occurs because there is not a direct correspondence between raw fish and final product-form. That is, deliveries of fish with identical characteristics are not necessarily directed to the same final market. Moreover, different firms have different processing costs; consequently, the price received by fishers can vary from company to company even though all the product may arrive in the same final market.[2]

In the intermediate market for net-caught salmon, there exists a uniform minimum or floor price for each species. This minimum price is determined through negotiations between representatives of processors and fishers. The majority of large fish processors belong to the Fisheries Council of British Columbia. This organization bargains with the United Fishermen and Allied Workers Union (UFAWU) and the Native Brotherhood in order to arrive at a minimum price for each species of net-caught salmon prior to the season opening. The UFAWU represents all crew members on salmon seine vessels, a high percentage of independent gillnet fishers, and a small percentage of the troll fishers. The Native Brotherhood represents and bargains on behalf of the majority of Indian fishers on the Pacific coast (Shaffer, 1979:29-30). The minimum prices are

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[1]DPA Group, Inc., 1986.

[2]DPA Group, Inc., 1986.

negotiated in June or early July, and generally reflect a conservative projection for canned salmon prices. Such projections are, in turn, dependent upon projected landings in B.C., Japan and Alaska, world-wide inventories, exchange rates and interest rates.[3]

The UFAWU and the Fisheries Council of B.C. negotiate two herring pricing agreements prior to the onset of the fishing season: one covering seine vessels, and the other covering gillnet vessels. The seine agreement actually sets the minimum price per ton to be shared by the vessels' crews; it does not fix the landed price. This is much closer to a wage settlement than is the salmon agreement because it covers only the crew and makes no provisions for equipment, fuel, or a return to the vessel. The negotiated minimum price to gillnetters is substantially more than that for seine-caught roe herring. This price, which includes a return to both capital and labour, more closely approximates the actual landed price (Schwindt, 1982:105). Although these negotiated prices set a floor at the outset of the season, the final price paid to fishers depends upon the contractual arrangements between the fishers and the processors and between the processor and the Japanese importer. It also depends upon the pricing dynamics on the fishing grounds.

Although there exist a multitude of contractual arrangements between fishers and processors, it is useful to define two broad categories of arrangments: spot-market transactions and incomplete, long-term contractual arrangements.

Spot-Market Transactions

On the one hand there exist "arms length" transactions between fishers and purchasers. Each party undertakes their requisite seasonal investments prior to the season-opening. For example, the fisher prepares his/her vessel, and hires a crew, etc.,

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[3]DPA Group, Inc., 1986.

and the processor invests in processing capacity and equipment, and hires labour, etc. It is only after the season has opened and a vessel-load of raw fish has been "produced", that the fisher seeks an exchange opportunity with a potential purchaser. The majority of troll-caught salmon is traded under this arrangement, as is a significant amount of net-caught salmon. Such exchanges generally take place "on-the-grounds" between the fisher and a "cash buyer"[4]. The price on the grounds for net-caught and troll-caught salmon is mainly set by fresh/frozen market forces. If the fresh/frozen market is strong relative to the canned market, the grounds price for net-caught fish will be above the minimum price. Since troll prices are not bound by the minimum price agreement, they tend to be more volatile than in-season net prices.

Incomplete Long-Term Contracts

The second arrangement under which raw fish is transacted involves measures taken prior to delivery. That is, a fisher and a purchaser will agree to exchange with one another prior to the opening of the fishing season. Such arrangements are usually established between large processors and salmon seiners. Medium-sized processors and gillnetters also use this arrangement, but to a lesser extent. Note that these arrangements are not generally defined in explicit, legally enforceable, written contracts. Rather, there exists an implicit understanding between the two parties: all fish of a particular species harvested by the fisher will be delivered to the processor; in turn, the processor assures the fisher that all fish that he/she harvests will be purchased.

Processors operating under this arrangement generally "book" the fish at the time of delivery. That is, they credit fishers for their catch at the prices prevailing in the area at the time of delivery. In some years the price for booked fish is equal to the minimum

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[4]Cash buyers do not operate shore services and ususally locate close to major population centers in the Lower Mainland. They often have an order for a specific amount of a particular product at a guaranteed price. They operate in the fresh/frozen market and turn over the product quickly, often within 24 hours of taking delivery.

price; in other years it exceeds the minimum price.[5] In addition to the book price many fishers are also compensated at year-end with "bonuses". The structure of bonus payments has changed over the years. In the mid- to late-1970s, bonuses were paid in the form "x cents per pound plus y percent of the book price". Since 1980, the bonus payment structure has been on a straight percentage basis (i.e., y percent of the book price times pounds delivered). Today, sockeye generally command a higher bonus percentage than other species.[6]

An additional characteristic of these "non-arms-length" transactions is the existence of non-monetary compensation from salmon purchasers to fishers. Such compensation includes: fish packing and collection services; vessel financing; the provision of ice, nets, lofts and moorage; vessel maintenance; the financing of inter- and intra-seasonal operating expenses; the provision of the vessel itself; and accounting and banking services.

The intermediate market for roe herring is similar to that for raw salmon in that there exist both arms-length and non-arms-length arrangements. On the one hand, the major processors establish vertical ties with fishers, similar to those described for the salmon fishery. Cash buyers representing smaller processors typically engage in rigorous price competition for the roe herring. In both the salmon and herring fisheries, there is a clear motivation for the fishers to deal with the cash buyers, despite their formal or informal commitments to the major processors. The cash buyers pay more than the going grounds' prices and also pay in cash, with little attention given to such formalities as the Income Tax Act. The major processors have actually been known to hire aircraft to police the fishing grounds, thereby ensuring that commitments are fulfilled (Schwindt, 1982:107).

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[5] DPA Group, Inc., 1986
[6] DPA Group, Inc., 1986

The structure of the market for raw halibut is relatively straightforward. Total supply of Pacific halibut is regulated by International Pacific Halibut Commission. The Commission sets a catch quota for the fishery, oversees gear regulations and closures, and delimits the actual fishing season. Unlike the salmon and roe herring fisheries, the UFAWU plays a very limited role in the determination of landed prices for halibut. An agreement does exist between the union and some longline fishing vessel owners, but it is essentially a crew-share agreement and not a price agreement (Schwindt, 1982:114).

The landed price for halibut is determined in auction markets or through direct negotiations between fishers and buyers, either in Canada or the United States. Auction markets exist in Prince Rupert and in several American ports, and fishers may sell through these institutions. There exists a significant degree of arbitrage across auction markets, facilitated by the use of radiophones (Schwindt, 1982:115).

Like halibut, the price for sablefish appears to be competitively determined. The UFAWU does not negotiate landed prices but does have a long-standing share agreement with the vessel owners. Landed prices are negotiated with the fishers upon delivery of fish. Nominal bonuses are rarely paid and do not compare with those in the salmon and roe herring fisheries (Schwindt, 1982:120).

The foregoing discussion indicates that salmon trollers, halibut and sablefish fishers rely predominantly on spot-market arrangements. Salmon and herring seiners, and to a lesser extent gillnetters, are more likely to rely on incomplete long-term contracts in order to exchange raw fish. In the past, these assertions have been only casually supported; that is, they are supported by discussions between fisheries managers/researchers and industry participants (egs., fishers, plant managers). A major contribution of this thesis is the collection and compilation of data regarding vertical ties

between fishers and processors. This information is then related to other characteristics of the harvesting and processing operations.

As noted previously, there exist many different types of vertical ties between fishers and processors.[7] Although an exhaustive set of data on all vertical ties is not provided, this thesis does provide, for a very large sample, information on vessel ownership, vessel financing and the payment of season-end bonuses. This information is then related to other characteristics of individual transactions between fishers and processors.

B. Presentation of the Data

Information on vessel ownership and debt has been obtained from the Ship's Registry. This information is available only for those vessels that are "registered" with a Canadian port. Registration is a legal requirement for vessels that meet certain specifications with respect to size and weight. The majority of commercial fishing vessels meet these specifications and are thus registered. This information was obtained for all vessels that were licensed to fish either salmon, herring, halibut, or sablefish in the 1990/1991 season and results in a sample of 3,255 vessels. Note that many of the vessels included in this sample also participated in fisheries in addition to the four specified above.

The 1988 Cost and Earnings Survey, conducted by the Department of Fisheries Oceans, provides information on total earnings and season-end bonuses by fishery, and identifies the gear-types employed, for a large subset of B.C. commercial fishing vessels. From this subset, I have selected for my sample those respondents that participated in at

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[7]Recall that the various vertical ties include fish packing and collection services, vessel financing, the provision of ice, nets, lofts and moorage, etc.

least one of the salmon, halibut, herring, or sablefish fisheries. This selection criterion results in a sample of 568 vessels. A somewhat unfortunate characteristic of this sample stems from the fact that the 1988 Cost and Earnings Survey was "boycotted" by processor-owned vessels. It would be informative to observe the incidence of season-end bonuses across processor-owned vessels relative to non-processor-owned vessels.

For each of the vessels in both samples, the Statistics Branch of the Department of Fisheries and Oceans has provided data on the distribution of each delivery across species, sub-species, gear-type, delivered product-form, and buyer. For each of the companies that purchased salmon, herring, halibut and/or sablefish, the B.C. Ministry of Agriculture and Fisheries has provided data on the distribution of wholesale earnings across species, sub-species, and final product-form.

Table 3-1 summarizes ownership and debt information for a total of 3,255 commercial fishing vessels, all of which participated in at least one of the salmon, herring, halibut or sablefish fisheries in the 1990/1991 fishing season. There are 64 ownership shares attached to all commercial fishing vessels. The majority of the vessels (1,861 or 57%) in the sample are entirely owned by one individual; 319 vessels, or 10% of the sample, are jointly owned (that is, each of the 64 shares are jointly owned by two or more individuals); 99 vessels (3% of the sample) have the 64 shares distributed (equally or unequally) across two or more individuals in a partnership; 707 vessels (22% of the sample) are either fully or partially owned by an incorporated enterprise, exclusive of any processors; and 269 (8% of the sample) are fully or partially owned by processors. The low proportion of processor-owned vessels is partly due to a government restriction. Under the terms of the salmon licence limitation program, implemented by the Davis Plan in 1968, direct processor ownership of the salmon fleet is limited to 12%.

	Individual Ownership	Joint Ownership	Partner- ship	Incorporated Enterprise	Processor Ownership	Total
No Debt	634	102	28	237	123	1124
Debt Held With Individual(s) or Financial Institution(s)	918	201	62	398	86	1665
Debt Held With Processor	309	16	9	74	60	468
Total	1861	319	99	707	269	3255

Table 3-1: OWNERSHIP AND DEBT INFORMATION OF REGISTERED FISHING VESSELS, 1991

The majority of the vessels in this sample (1,665 or 51%) serve as collateral on debt held with either individuals or financial institutions; there is no vessel-associated debt for 1,124 vessels (34% of the sample); and 468 vessels (14% of the sample) served as collateral on debt held with processors.

Processor ownership and processor financing of the fishing vessel are two types of vertical ties existing between fishers and processors. Table 3-2 summarizes the way in which the ownership status of vessels varies across gear-types employed in the harvesting sector.

The last column shows the total number of sample vessels belonging to each gear category. For example, of the 3,255 vessels in the sample, 506 were equipped with only seine gear, 360 with only gillnet gear, and 464 with only troll gear. The sample also

consists of a number of vessels equipped with multiple gear-types. For example, 1,544 vessels used combination (gillnet and troll) gear, 59 employed both longline and trap gear, 211 used combination gear, longline gear and trap gear, etc.

The information of particular significance in this table is the fact that the most common type of ownership for the "seine-only" vessels is that of processor or wholesaler ownership. Specifically, 211 of the 506 seiners, or 42%, have wholesaler ownership interest. The second most common type of ownership for "seine-only" gear is that of an incorporated (non-processing) enterprise; specifically, 161 of the 506 "seine-only" vessels, or 32%, were owned by incorporated enterprises. The remaining 26% of "seine-only" vessels were distributed across the other categories of ownership: individual or joint ownership, or a partnership arrangement.

No other gear-type category has processor ownership as the predominant type of vessel ownership. For example, the most common type of ownership for gillnet, troll, and combination gear is that by individuals; indeed, for these gear-types, processor ownership is the least common type of vessel ownership. The most common for longline/trap gear is that by non-processor incorporated enterprise.

This data suggests that there may be a link between contractual choice in the intermediate market for raw fish and attributes of the harvesting technology employed in transactions. In particular, the data indicates that seine gear may have attributes that increase the tendency for the transacting parties to establish vertical ties.

Table 3-3 depicts the debt-status of the 2,986 non-processor owned vessels across gear-type categories. As illustrated, 295 of the non-processor owned vessels employed only seine gear, 357 employed only gillnet gear, etc. Note that the majority of these "seine-only" vessels are financed by either individuals or financial institutions (133 of the 295 vessels, or 45%). However, a larger proportion of "seine-only" vessels

Table 3-2: OWNERSHIP STATUS OF REGISTERED VESSELS ACROSS GEAR-TYPE, 1991

	Individual Ownership	Jointly Owned	Partner- Ship	Incorporated Enterprise	Processor Ownership	Total
Seine Gear Only	99	9	26	151	211	506
Gillnet Gear Only	265	45	7	40	3	360
Troll Gear Only	300	75	18	66	5	464
Combination G/T Gear	1052	161	39	278	14	1544
Longline/ Trap	13	1	1	27	17	59
Seine/Long- line/Trap	3	1	3	28	14	49
Gillnet/Long- line/Trap	5	3	0	0	0	8
Troll/Long- line/Trap	16	5	1	29	3	54
Combination/ Longline/Trap	108	19	4	78	2	211
Total	1861	319	99	707	269	3255

(86 of 295, or 29%) have processor debt than any of the other gear-type categories. The gear-type category that has the second largest proportion of vessels financed by processors is that identified as "seine/longline/trap". Observe that there are 35 vessels in the sample that employ these three gear-types; 9 of the 35 (26%) were financed by processors. Thus, although processors are not the dominant source of financing for any of the gear-type categories, seiners do rely more heavily on processor-financing than do other vessels.

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Table 3-3: DEBT STATUS OF NON-PROCESSOR OWNED VESSELS ACROSS GEAR, 1991

	No Debt	Debt Held With Individual(s) or Financial Institution(s)	Debt Held With Processor	Total
Seine Gear Only	76	133	86	295
Gillnet Gear Only	126	195	36	357
Troll Gear Only	164	269	26	459
Combination S/T Gear	533	784	213	1530
Longline/ Trap	12	23	7	42
Seine/Long-line/Trap	9	17	9	35
Gillnet/Long-line/Trap	6	2	0	8
Troll/Long-line/Trap	15	34	2	51
Combination/ Longline/Trap	59	124	26	209
Total	1000	1578	408	2986

Looking at the information in tables 3-2 and 3-3 together, observe that there is a total of 506 vessels that employed seine gear alone. Fifty-nine percent, or 320 of these 555 vessels, are either owned by a processor or have debt with a processor. For no other gear-type category is the incidence of these particular vertical ties as high. For example,

gear-type category is the incidence of these particular vertical ties as high. For example, of the 360 vessels employing gillnet gear alone, 39 or 11% of them are owned or financed by a processor. Of the 464 vessels employing only troll gear, 31 or 7% exhibit one of these vertical ties with a processor. The second-highest incidence of vertical ties occurs in the longline/trap category, where 24 of the 59 vessels (or 41%) are either owned or financed by processors. None of the vessels in the sample employ only one of longline or trap gear; thus, it is not possible from the information given in tables 3-2 and 3-3 to determine which of these gear-types, if any, motivates the formation of vertical ties. The high proportion of seine vessels that are owned or financed by processors is of particular significance when considering the facts that, seine gear alone accounts for approximately 50% of the total salmon catch, and for 56% of the herring landings.

Table 3-4 summarizes the Cost & Earnings Survey information on season-end bonus payments. There are a total of 568 survey respondents in my sample: 540 vessels participated in the salmon fishery, 97 in the roe herring fishery, 96 in the halibut fishery and 27 in the sablefish fishery. These are not mutually exclusive categories. That is, some vessels participated in more than one of these fisheries. Column 3 indicates that 183 of the 540 salmon vessels, or 34%, received a salmon bonus; 14 of the 97 vessels fishing herring, or 14%, received a herring bonus; 1 halibut vessel received a bonus, and 2 sablefish vessels received bonuses. Column 4 indicates the average size of the bonus received as a percentage of total earnings, as reported in the survey. Averaging the size of the salmon bonus over the 183 vessels that reported receiving a bonus, it is found that this bonus constituted 24% of their salmon earnings in 1988. Similarly, of the 14 vessels receiving herring bonuses, the bonus, on average, accounted for 17% of total earnings. Given the very small number of halibut and sablefish vessels reporting bonuses, little importance can be attached to the size of these bonuses.

The information in Table 3-4 indicates that salmon and, to a lesser extent, herring, may have characteristics which induce vertical ties between fishers and processors. Table 3-5 illustrates the way in which the incidence and size of bonuses vary across the gear-types employed in each fishery. Of the 118 vessels in the sample that employed salmon seine gear, 72, or 61% reported receiving a bonus; the average size of this bonus as a percentage of earnings was 31%. Similarly, 16% of salmon gillnetters received bonuses, the average size of which was 12% of salmon earnings; 33% of salmon trollers received bonuses, the average size of which was 7% of salmon earnings. Thirty percent of salmon combination gillnet/trollers received an average bonus of 5% of salmon earnings. With respect to the herring fishery, bonuses were also more common among seiners than gillnetters, and were also larger as a percentage of herring income. Thus, the information in Table 3-5 adds further support to the possibility that some characteristics of seine gear may motivate fishers and processors to establish vertical ties. Not only does the payment of season-end bonuses appear to be more common to seiners, but the size of these bonuses are larger than those to vessels employing other gear-types.

The information provided in tables 3-1 - 3-5 establishes that there do exist empirical regularities between the incidence of vertical ties and certain aspects of the harvesting sector. In particular, vertical ties appear to be most common in the salmon fishery and with vessels employing seine gear. Are there any empirical regularities regarding the incidence of vertical ties and aspects of the processing sector?

Table 3-4: NUMBER OF VESSELS RECEIVING BONUSES AND AVERAGE SIZE OF

BONUS ACROSS SPECIES, 1988*

Species	Total Number of Vessels(1)	Number of Vessels Receiving Bonus(2)	Average Size of Bonus(3)
Salmon	540 (95%)	183 (34%)	24%
Herring	97 (17%)	14 (14%)	17%
Halibut	96 (17%)	1 (1%)	32%
Sablefish	27 (5%)	2 (7%)	4%

*Based on a sample of 568 vessels that responded to the Department of Fisheries and Oceans 1988 Cost & Earnings Survey

(1) The bracketed terms refer to the percentage of sample vessels reporting earnings from the corresponding species category

(2) The bracketed terms refer to the percentage of vessels in the corresponding species category that received a bonus

(3) Refers to bonus as a percent of total earnings from the corresponding species category; includes only those vessels that received a bonus from deliveries of that species (i.e., [bonus / total earnings from species]x100)

Table 3-5: NUMBER OF VESSELS RECEIVING BONUSES AND AVERAGE SIZE OF BONUS

ACROSS GEAR-TYPE, 1988*

Gear Type	Total Number of Vessels(1)	Number of Vessels Receiving Bonus(2)	Average Size of Bonus(3)
Salmon Seine	118 (21%)	72 (61%)	31%
Salmon Gillnet	147 (26%)	23 (16%)	12%
Salmon Troll	170 (30%)	56 (33%)	7%
Combination Salmon Gillnet-Troll	105 (18%)	32 (30%)	5%
Herring Seine	39 (7%)	9 (23%)	18%
Herring Gillnet	59 (10%)	5 (9%)	12%
Halibut Longline	96 (17%)	1 (1%)	32%
Sablefish Longline	17 (3%)	0	-
Sablefish Trap	11 (2%)	2 (18%)	4%

* Based on a sample of 568 vessels responding to the Department of Fisheries and Oceans 1988 Cost & Earnings Survey

(1) Bracketed terms refer to the percentage of sample vessels that reported earnings from the corresponding gear-type category

(2) Bracketed terms refer to the percentage of vessels in the corresponding gear-type category that received a bonus for deliveries deriving from that gear-type

(3) Refers to bonus as a percent of total earnings from deliveries made with the corresponding gear-type; averaged over only those vessels that received a bonus (i.e., [bonus / total earnings]x100)

Table 3-6: AVERAGE PROPORTION OF WHOLESALE EARNINGS FROM FISH

PROCESSING ACROSS SPECIES AND ACROSS PROCESSORS

CATEGORIZED BY OWNERSHIP AND INVESTMENT IN VESSELS, 1988

	Processors Owning Vessels	Processors Holding Debt in Non-Processor Owned Vessels	Processors that Neither Own or Hold Debt in Vessels
Number of Companies	9	10	113
Average Proportion of Earnings From Salmon Sales	61.9%	53.3%	61.9%
Average Proportion of Earnings from Herring Sales	19%	12.8%	3.9%
Average Proportion of Earnings From Halibut Sales	12.3%	4.3%	2.3%
Average Proportion of Earnings From Sablefish Sales	0.4%	0.7%	2.5%
Average Proportion of Earnings From Other Species	6.4%	28.9%	29.4%

Table 3-6 summarizes the relationship between the proportion of wholesale earnings derived from the different fisheries and processor ownership and financing of harvesting operations. In 1988 there were 132 wholesalers that derived revenue from the

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sale of at least one of the fish species under consideration. Nine of these processors owned commercial fishing vessels, and an additional ten provided financing to commercial fishing operations. The nine wholesalers that had direct ownership in vessels received an average of 61.9% of fish wholesale earnings from salmon sales, 19% from herring sales, 12.3% from halibut sales, 0.4% from sablefish sales, and 6.4% from sales of other species. Thus, salmon and herring together account for approximately 81% of wholesale earnings for these firms. With respect to the wholesalers that financed fishing operations, salmon and herring together accounted for about 66% of wholesale revenues. Processors that neither owned nor financed harvesting operations also derived approximately 66% of wholesale revenues from the sale of salmon and herring products.

This data suggests that processors relying heavily on revenues from salmon or herring products are more likely to own vessels than firms relying to a lesser extent on these species. Casual observation of the data, however, does not suggest a connection between the distribution of wholesale revenue across species and the tendency of a processor to finance a vessel.

Table 3-7 shows the way in which the average proportion of wholesale earnings from different final product-forms varies across these same groups of processors. This data suggests a strong connection between the existence of vertical ties and the processors' reliance on canned salmon and herring roe earnings.

The nine processors that owned vessels received an average of 19% of wholesale earnings from the sale of "own-canned" salmon (i.e., salmon canned by the wholesaler); an average of 3.5% of wholesale earnings came from the sale of "custom-canned" salmon (i.e., salmon canned by another processor and sold back to the wholesaler). Similarly, these nine vessels received 13.5% of earnings from the sales of fresh salmon, 23% from the sale of frozen salmon, 16.2% of from the sale of processed herring roe, 11.6% from the sale of fresh halibut, and 9.7% from the sale of other species. Additional

wholesale revenues are earned from relatively insignificant sales of smoked salmon, salmon roe, frozen halibut, and sablefish. Note that these processor having ownership in fishing vessels made 35.2% of their wholesale earnings from own-canned salmon and herring roe combined.

The 10 processors that did not own vessels but did finance vessels relied much less heavily on earnings from the production of own-canned salmon (1.3% of wholesale revenue) and herring roe (3.5%) and much more heavily on earnings from other species. These 10 processors thus derived 4.8% of their earnings from own-canned salmon and herring roe.

The 113 wholesalers who neither owned nor financed fishing vessels received virtually no earnings from the sale of own-canned salmon (0.14%) and very little from herring roe (1.5%). Thus, less than 2% of wholesale earnings were derived from the sale of own-canned salmon and herring roe for these processors.

Thus, processors establishing very strong vertical ties with fishers (i.e., vessel ownership) rely very heavily on earnings from own-canned salmon and herring roe. Conversely, processors without strong vertical ties (i.e., neither owning nor financing vessels) exhibit almost no reliance on earnings from these two product-forms.

Table 3-8 shows the way in which the average proportion of wholesale earnings from different final product-forms varies across bonus-paying and non-bonus-paying processors. Note that there were 16 companies in 1988 that paid a season-end bonus, while 116 companies in the sample did not pay bonuses. Observe the average distribution of wholesale earnings across final product-form for those companies paying season-end bonuses. These companies received, on average, 11% of wholesale earnings from the sale of own-canned salmon, 33.4% from the sale of frozen salmon, and 13.8% from herring roe sales. Companies that paid no bonus relied much less heavily on wholesale earnings from these categories of final product-form. For example, on average, only

0.14% of wholesale earnings was derived from the sale of own-canned salmon, 20.6% from frozen salmon and 1.1% from herring roe.

The purpose of this thesis is to explain the variation in contractual arrangements that exist both across and within these fisheries. Specifically: Why are troll-caught salmon, halibut and sablefish primarily exchanged under arms' length transactions, while seine-caught salmon and herring are traded between fishers and processors having strong vertical ties with one another? Why do processors that rely more heavily on canned salmon and herring roe revenues establish stronger vertical ties with fishers than do those wholesalers relying less heavily on these final product-forms?

Table 3-7: AVERAGE PROPORTION OF WHOLESALE EARNINGS FROM FISH-PROCESSING ACROSS FINAL PRODUCT-FORM, AND ACROSS COMPANIES CATEGORIZED BY OWNERSHIP AND INVESTMENT IN VESSELS, 1988

	Processors Owning Vessels	Processors Holding Debt in Non-Processor Owned Vessels	Processors that Paid Bonuses	Processors that Neither Own or Hold Debt in Vessels
Number of Processors	9	10	16	113
Own-Canned Salmon	19%	1.3%	11.0%	0.14%
Custom-Canned Salmon	3.5%	2.5%	3.0%	4.4%
Fresh Salmon	13.5%	5.8%	10.3%	15.9%
Frozen Salmon	23%	38.9%	33.4%	20.6%
Smoked Salmon	0.7%	4.1%	0.6%	16.7%
Salmon Roe	1.9%	0.6%	1.3%	3.4%
Herring Roe	16.2%	3.5%	13.8%	1.5%
Fresh Halibut	11.6%	3.0%	1.4%	1.5%
Frozen Halibut	0.7%	0.9%	2.2%	0.7%
Fresh Sablefish	0.0%	0.0%	0.0%	0.14%
Frozen Sablefish	0.2%	0.6%	1.7%	2.0%
Smoked Sablefish	0.0%	0.0%	0.0%	0.3%
Other Species	9.7%	38.8%	20.8%	32.7%

Table 3-8: AVERAGE PROPORTION OF WHOLESALE EARNINGS BY PRODUCT-FORM ACROSS COMPANIES CATEGORIZED BY BONUS PAYMENTS, 1988

	Companies that Paid Bonuses	Companies that Paid no Bonus
Number of Processors	16	116
Own-Canned Salmon	11%	0.14%
Custom Canned Salmon	3.0%	4.4%
Fresh Salmon	10.3%	15.6%
Frozen Salmon	33.4%	20.6%
Smoked Salmon	0.6%	16.6%
Salmon Roe	1.3%	3.4%
Herring Roe	13.8%	1.1%
Fresh Halibut	1.4%	2.5%
Frozen Halibut	2.2%	0.5%
Fresh Sablefish	0.0%	0.14%
Frozen Sablefish	1.7%	1.8%
Smoked Sablefish	0.0%	0.3%
Other	20.8%	32.9%

CHAPTER 4: LITERATURE REVIEW

The purpose of this chapter is to review prominent theories of vertical integration and/or contractual structure in order to determine their relevance to observed contractual arrangements in the intermediate market for raw fish. First, it is useful to reiterate the contractual structure we are trying to explain. The vast majority of transactions in the B.C. intermediate market for raw fish are conducted in one of two ways: autonomous, or arms' length, exchange; or through incomplete long-term contracts characterized by non-price compensation (i.e., processor provision of vessel, gear, financing, maintenance, ice, storage, accounting and banking services, and/or season-end bonuses). The appropriate paradigm must explain two things:

1. the structure of the long-term contract; that is, why are fishers compensated with non-price payments?
2. the empirical regularities regarding contractual choice;

There exists a large body of literature dealing with the efficacious exchange of products between stages of production and distribution. At a rudimentary level, the primary distinction is between inter-firm and intra-firm transactions. The latter involves the owner of a firm undertaking the production of an intermediate input, or integrating forward into the production of a final product. An inter-firm transaction, on the other hand, involves the owner of the downstream firm purchasing the intermediate input from a separately owned upstream firm.

The usefulness of the above distinction is limited in that there are a variety of ways to complete each of inter-firm and intra-firm transactions. That is, between the two polar extremes of outright ownership and autonomous contracting are a multitude of complex contractual arrangements. Thus, rather than explicitly distinguishing between inter-firm and intra-firm transactions, it is convenient to define an exchange as taking place under a particular "governance structure"[1].

Much of the literature focuses on how costs of production and/or transaction vary across different governance structures. The technological relationship between the harvesting and processing of raw fish renders some of this literature inapplicable. In particular, the harvesting and processing stages of production are completely separable. Moreover, no technological economies of scale are generated in the production of either the intermediate or final product when the ownership of the operations is combined.

Two main bodies of literature potentially contribute to the understanding of how transactions are completed in the intermediate market for raw fish. One posits that the choice of contractual arrangement is motivated by the pursuit or maintenance of market power. The other maintains that the rules governing transactions are adopted so as to minimize the cost of transacting.[2] Although not all of the theories considered within this second category are generally recognized as "transaction-cost" theories, I adopt Williamson's view that "...the vertical integration of technologically separable production stages ultimately turns on transactional considerations"[3].

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[1]Williamson, 1975.
[2]Note that these two categories of explanation are not mutually exclusive.
[3]Williamson, 1975:83.

Market Power Incentives

A few studies have explicitly attempted to explain the industrial organization of the intermediate market for raw fish. In rationalizing the use of non-price compensation mechanisms, each of these studies points to the pursuit or maintenance of market power in the processing sector as being the prime determinant of contractual choice.

Strategic Collusion

Shaffer (1979), Schwindt (1982) and Pinkerton (1987) have independently studied the structure of the British Columbia intermediate market for raw fish. Shaffer focused exclusively on the salmon fishery, while Schwindt and Pinkerton covered several fisheries, including the salmon fishery.

The overriding theme in the three studies is that non-price competition promotes collusive behaviour among processors, the goal of which is to avoid "destructive" price competition. In general, then, the three studies suggest that the contractual structure in the intermediate market for raw fish is chosen so as to promote strategic collusion. Shaffer asserts that "... because of the concentration of buying in the raw salmon markets, the buyers are aware of their mutual dependence; they are aware of the self-defeating nature of price competition. . . . Consequently, the buyers try to engage in non-price as opposed to price competition."[4] Similarly, Schwindt maintains that "....the existence of this type of non-price competition is not surprising. The market is characterized by oligopsony, and by their nature oligopsonists are loath to enter into price competition, especially for a homogeneous product."[5] Pinkerton (1987) also alludes to strategic collusive behaviour on the part of processors: "The supply of fish is limited, and neither large nor small firms wish to attract further entry nor bid up the price too much. Firms . . . find it convenient to cooperate in various ways, including holding

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[4]Shaffer, 1979:11.
[5]Schwindt, 1982:34.

raw fish prices low."[6] "Competition by processors in the provision of services to fishers is simultaneously the most direct method of acquiring supply and of avoiding price competition."[7] This is particularly important, according to Pinkerton, for canners. who are dependent on securing enough volume to lower production costs.[8]

Thus, these authors each assert that, because the market for raw salmon is oligopsonistic, processors have the opportunity, through implicit or explicit collusion, to keep the price of raw salmon lower than would be possible if the buyers' side of the market was more competitive. When processors offer a higher price for raw fish in order to attract supply, other firms in the industry are likely to respond by doing the same in order to maintain their share of the raw fish supply. As the price of raw fish rises, processors' profits are eroded. Thus, such behaviour is viewed as "destructive" price competition.

Of course, non-price compensation (egs., the provision of bonuses and ancillary services) is itself costly, and, therefore, inversely related to processors' profits. Thus, the erosion of profits is not avoided by the partial replacement of price compensation with non-price compensation mechanisms. Under what circumstances, then, does the practice of non-price competition serve the interest of a collusive oligopsony? That is, is it consistent to collude with respect to price, but not with respect to other aspects (i.e., non-price aspects) of the transaction?

The intent of collusion among oligopsonists is to maximize joint profits. Traditional formulations of the oligopoly problem conclude that the joint profits of firms in an industry are maximized when they act together as a monopolist. Stigler (1964)

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[6]Pinkerton, 1987:74

[7]Pinkerton, 1987:75

[8]In order for larger supplies of fish to result in lower production costs, there must exist economies of scale in canning. Although Pinkerton insists that large firm do enjoy economies of scale in canning, Schwindt and Shaffer insist that economies of scale are insignificant beyond the medium-sized firm. The point, however, is that if canners do experience economies of scale and attempt to ensure adequate supplies for themselves, why employ non-price compensation rather than price compensation?

modifies this theory by presenting an account of the factors governing the feasibility of collusion. The success of any collusive agreement rests upon the ability to enforce the agreement. "Enforcement consists basically of detecting significant deviations in the agreed-upon prices."[9] Given detection, deviation from the collusive price by any one firm will no longer be profitable since it will be matched by other firms. Schwindt (1982) justifies the use of non-price compensation as follows: "Defection by any processor from a given price level is easily detected by, and communicated amongst, fishermen. . . The provision of services is both difficult to valuate and difficult to police, and thus provides an ideal method of competing."[10] Thus, if non-price variation is less observable or measurable than changes in per-unit prices, it is conceivable that an oligopsonistic firm could use such methods to attract fish supplies without starting a "price" or a "non-price" war.

If, however, enforcement is weak, owing to lags in detection and/or incomplete detection, the collusive agreement is rendered ineffective. We would expect firms collectively seeking joint profit maximization to revise the agreement so that the inducements to raising non-price compensation were small, or to restrict collusive behaviour to areas in which effective enforcement were possible.

Thus, it does not appear that processors that use non-price compensation are attempting to protect themselves from competition with each other. The above discussion indicates that non-price compensation hinders rather than promotes such an objective. However, competition in non-price services may serve to protect processors that use non-price compensation from those who do not and/or may serve to prevent entry.

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[9]Stigler, 1964:47.
[10]Schwindt, 1982:34

Strategic Entry Deterrence

Non-autonomous contracting for the intermediate product may serve to support a non-competitive market structure by promoting entry barriers. For example, suppose a downstream firm procures supplies of the intermediate input, either through vertical integration or, say, an exclusive dealing arrangement. In some cases, such procurement of the intermediate input may make it more difficult for new firms to enter the industry (Aghion and Bolton, 1987; Krattenmaker and Salop, 1986; McAfee and McMillan, 1986; Rey and Tirole, 1986). In order to participate in the downstream industry, a potential entrant will either have to undertake production of the intermediate input, or purchase the input from established rivals. In the first instance, the potential entrant's sunk costs of production are higher than would be otherwise. In addition to investing in processing facilities, the entrant would also have to invest in harvesting capacity (i.e., vessel, gear, etc.). The established firms, having already incurred these harvesting costs, may attempt to deter entry by lowering the price of the final product so as to render entry unprofitable. Similarly, if a potential entrant, rather than integrating backward, were to attempt to purchase the intermediate input from an established rival, it may also be at a cost disadvantage. While the established firm would supply itself with the input at marginal cost, it is unlikely to practice marginal-cost pricing in its sales to a rival firm. If established processors own the majority of raw fish supplies, and if the processing sector is not competitive, an established firm will maximize profits from sales of the intermediate input by charging a price that exceeds the marginal cost of producing the intermediate input.

Shaffer (1979) conducted an economic study of the structure of the B.C. salmon industry, the purpose of which was to determine the implications of industry structure for industry behaviour and performance. He explicitly adopts the "limit-pricing model" in

explaining the pricing behaviour of the B.C. salmon processing sector. Specifically, he maintains that the oligopsonistic processors collude so as to prevent the entry of additional firms. That is, the "total price" (money price + non-price compensation) for the intermediate product is set high enough so that a potential entrant finds entry unprofitable. The non-price compensation mechanisms (i.e., provision of vessel, credit, services, etc.) are viewed as a barrier to the entry of new wholesalers. A new entrant would have to "lure" fishers away from processors with whom they have vertical ties in order to participate in the market.

Does the empirical evidence offered in the previous chapter support the hypothesis that non-price compensation is strategically used to deter entry into the B.C. processing sector? The data indicates that non-price compensation is most common in exchanges between salmon canners and salmon seiners, and between processors of herring roe and herring seiners. In order for this hypothesis to be consistent with the data, it must be explained why salmon canners and herring roe processors are more desirous of entry prevention, or better able to deter entry, than are other wholesalers.

Note that Shaffer's study was confined to the B.C. salmon industry. He noted, however, that buyer-seller ties were much greater for the traditionally-canned species (and net landings generally) than for the principal fresh/frozen species (and troll landings generally). He attributes the existence of entry prevention through non-price competition in the salmon canning sector, and its absence in the fresh/frozen salmon market, to the fact that the canning sector is a "strong oligopsony", while the buyers operating in the fresh/frozen market form a "weak oligopsony". As such, fresh/frozen wholesalers ". . . are subject to a greater degree of price competition." (Shaffer, 1979: 76).

The distinction between "weak" and "strong" oligopsony is necessarily somewhat arbitrary. The measure used by Shaffer to characterize market structure is the share of salmon production-value by largest firms. In 1976, the three largest processors

accounted for 81.7% of the value of canned production and 48.7% of the value of fresh/frozen production; the five largest processors accounted for 89.1% of canned and 62.4% of fresh/frozen. Schwindt (1982) reports that, in 1980, the two largest enterprises accounted for 58.7% of canned production sales, and 54% of frozen production sales, while the four largest accounted for 76.1% of canned and 63% of frozen production sales. Thus, the distinction between "strong" and "weak" oligopsonies had become less pronounced by 1980.

Industry concentration statistics for 1988 are presented in Tables 4-1 and 4-2. Table 4-1 depicts, for each of the four species, the proportion of landed weight purchased across groups of firms. The information in Table 4-1 indicates that there is a high degree of industry concentration in the purchase of fish landings for all of the noted species, although this concentration is less pronounced for halibut purchases. The three largest firms in each fishery purchased 56.7% of the weight of salmon landings, 64.3% of herring landings, 67.7% of sablefish landings and 32.6% of halibut landings.

Table 4-2 shows the proportion of wholesale earnings by product-type across groups of firms. This information indicates that there is a high concentration of industry wholesale earnings in each of the product-types considered. This concentration is highest for smoked sablefish where the three largest firms accounted for 84% of wholesale earnings, followed by canned salmon where the three largest firms accounted for 82.9% of wholesale earnings, and then by fresh salmon, where the three largest firms accounted for 62.1% of wholesale earnings.

Support for the strategic collusion hypothesis would be indicated by a positive correlation between industry concentration and the incidence of non-price compensation. *Casual empiricism* does not offer this support, but nor does it indicate rejection of the strategic collusion hypothesis. The industry concentration data presented in Tables 4-1 and 4-2 indicates that purchases of all species and wholesale earnings from all final product-types are highly concentrated among a few firms. The data presented in Tables

3-7 and 3-8, however, indicates that non-price compensation is most commonly used by processors relying heavily on earnings from canned salmon and herring roe. Thus, non-price competition for raw fish supplies does not appear to vary across fisheries or final product form in the same way as does industry concentration. A more rigorous analysis of the correlation between industry concentration and the use of non-price compensation is undertaken in Chapter 6.

Although the market structure of the processing sector is considered by this author to have an important influence on the nature of the contract, concentration levels *alone* do not appear to explain observed variations in contractual arrangements across fisheries or across final product-forms. This thesis offers an alternative explanation for observed contractual structure in the intermediate market for raw fish. Note that the structure of the processing sector is not dismissed by this thesis as an important determinant to the structure of the contractual relationship existing between fishers and processors. Rather, it is the hypothesis that the contractual structure is chosen so as to promote or maintain market power among fish wholesalers/processors that is questionable. Even if fish processing was conducted within a competitive industry, it is possible that the transacting parties would rely, under certain circumstances, partially upon non-price compensation mechanisms.

Table 4-1: INDUSTRY CONCENTRATION OF DELIVERIES BY SPECIES, 1988

	Salmon	Herring	Halibut	Sablefish
3 Largest Firms	56.7%	64.3%	32.6%	67.7%
4 Largest Firms	62.8%	72.2%	38.8%	75.5%
Total Number of Firms	77	12	45	40

Source: Data compiled from unpublished statistics obtained from the
Statistics Division, Department of Fisheries and Oceans, Vancouver

Table 4-2: INDUSTRY CONCENTRATION OF FISH WHOLESALE EARNINGS BY

FINAL PRODUCT-FORM, 1988

	3 Largest Firms	4 Largest Firms	Total Number of Firms
Canned Salmon	82.9%	87.8%	27
Fresh Salmon	62.1%	71.4%	67
Frozen Salmon	37.6%	44.2%	70
Smoked Salmon	50.8%	59.9%	43
Salmon Roe	59.4%	67.0%	36
Fresh Halibut	47.3%	53.6%	39
Frozen Halibut	46.4%	58.2%	34
Fresh Sablefish	56.9%	62.9%	23
Frozen Sablefish	36.1%	40.8%	28
Smoked Sablefish	84.0%	88.5%	8
Herring Roe	60.0%	68.7%	14

Source: Data compiled from unpublished statistics obtained from the Ministry of
Fisheries and Agriculture, Province of British Columbia

Transaction Cost Economies

The importance of "transactions costs" in determining whether a transaction will take place across firms or within a single firm was recognized by Coase (1937). He stressed that, if an intra-firm transaction is deemed more profitable than an inter-firm transaction, there must be a cost to using the price mechanism. Coase (1937) and Williamson (1975) have distinguished four types of transaction costs. First, some contingencies that the parties to the transaction will face may not be foreseeable at the contracting date. Adapting to such circumstances when they occur may involve costly negotiations between the two parties. Second, even if they could be foreseen, there may be too many contingencies to write into the contract. Third, monitoring the contract, or ensuring that the other party abides by the terms of the contract, may be costly. Fourth, enforcing the contract, either through the legal system or the market mechanism, may be costly.

Risk-Bearing and Moral Hazard

The adoption of a particular governance structure may stem from the desire to remedy a moral hazard problem. Moral hazard problems arise because of the "conjoining of inharmonious incentives with uncertainty"[11]. On the one hand, the theory of optimal insurance demonstrates that the optimal division of profit between a risk-neutral party and a risk-averse party has the former bear all the risk, if incentive issues are left aside (Arrow, 1970; Borch, 1963). That is, the risk-averse party should have a constant income over all states of nature. On the other hand, such an insurance scheme eliminates the incentive of the risk-averse party to behave as a joint profit-maximizing agent (Hölmstrom, 1979; Shavell, 1979; Grossman and Hart, 1983).

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[11]Williamson, 1975.

Williamson (1975:84) illustrates the moral hazard problem by considering the problem of contracting for an intermediate good whose final cost is subject to uncertainty. Given that the supplier is risk-averse, a fixed-price contract to deliver a specific amount will be undertaken only if that price includes a risk premium acceptable to the supplier. A risk-neutral buyer may prefer to bear the risk by offering a cost-plus contract. This contract, however, impairs the incentives of the supplier to achieve least-cost performance. The integration of the two stages of production attenuates the opportunistic incentives of the supplier, and is also likely to reduce the monitoring costs of the buyer (Alchian and Demsetz, 1972).

Does non-price compensation from processors to fishers serve to reallocate risk between fishers and processors so as to reduce transactions costs and promote efficient exchange? Non-arms' length transactions involve processor-provision of some combination of vessel, gear, financing, repair and maintenance, ice, nets and lofts, and accounting and banking services. The fishers then receive a piece rate, determined at the time of exchange. This arrangement may be thought of as a variation of the "cost-plus" contract. A processor takes on a portion of the fisher's fixed costs; subsequent payments serve as a return on that portion of the investment undertaken by the fisher. In this way, the fisher's net earnings are subject to less variability than if the fisher absorbed all of the investment costs. This consideration would tend to support the possibility that contractual structure in the intermediate market for raw fish derives from risk-reallocation incentives if it could be demonstrated that fishers are more risk-averse than are wholesalers.

There does exist a high degree of uncertainty both with respect to supply of the intermediate input and, in some cases, the price of the final product. It is also likely that, in many cases, there is an asymmetry between supplier and buyer with respect to acceptable degrees of risk. Many buyers of raw fish purchase a variety of species and

many produce a variety of final product-types. These practices tend to insulate them from fluctuations in the input supply or final price of any one product.

Many fishers rely heavily on the catch of one particular species of fish caught with a particular gear-type. The earnings of these fishers are highly sensitive to fluctuations in the supply of that species and in fluctuations of expected wholesale prices. There also exist fishers who operate in several fisheries and whose earnings are, therefore, less sensitive to variations in the landed value of one species.

What kind of empirical evidence would support the risk-allocation hypothesis? We would expect that transactions involving fishers who are heavily dependent on income from one fishery, and processors that are very well insulated from intermediate and wholesale price fluctuations, would involve non-monetary compensation mechanisms. Conversely, the incidence of non-monetary compensation should be lower for those fishers less dependent on earnings from one species and trading with processors that are relatively less well insulated from price fluctuations.

The available empirical evidence does not refute the risk-allocation hypothesis. This thesis, however, offers an alternative rationale for the existence of non-price compensation mechanisms in long-term contracts between fishers and wholesalers.

The Hold-Up Problem

Klein, Crawford and Alchian (KCA) (1978) illustrate the effect of the potential for post-contractual opportunism upon the efficacy with which different governance structures permit the completion of a transaction. They consider a situation in which an asset is owned by an upstream firm that produces an intermediate input for a downstream firm. KCA maintain that as assets become more specific, the possible gain from opportunistic behaviour increases. That is, the less valuable are the supplier's investments in servicing an alternative customer, the more likely it is that the

downstream firm will take advantage of the low opportunity costs faced by the supplier. The downstream firm in the KCA example, having knowledge of the upstream firm's "next-best" rental opportunity, has an incentive to renege on its contractual obligations by reducing its rental offer *ex post*. Although the lower rental rate may have been unacceptable to the upstream firm prior to making the specific investment, the *ex post* absence of a more profitable alternative renders it in the best interest of the upstream firm to provide the service at the lower rental rate.

KCA submit that the problem of post-contractual opportunism can be avoided in one of the following ways:

1. The downstream firm could vertically integrate by itself investing in the specific asset, thereby removing the opportunity to hold-up the upstream firm.

2. A long-term contract could be formed between the two parties in which:

a) the terms of trade are explicitly stated for all contingencies, and legally enforceable by a third party; or

b) the terms of trade are implicitly agreed upon and the market mechanism is relied upon to enforce the contract via the imposition of a capital loss on the opportunistic party by the withdrawal of future business.

Since it is often very costly to specify in a written contract every contingency to which an optimal response is required, and because legal redress is expensive, the parties to the transaction will often prefer a market enforcement mechanism of the type (2b) over an explicit long-term contract. This contract is equivalent to Telser's (1980) "self-enforcing agreement" in which "...each party believes himself to be better off by continuing the agreement than he would be by ending it."[12]

The threat of termination alone, however, may not be sufficient to uphold the contract. Specifically, the one-time gain from contractual deviance may exceed the expected future net benefits from the trading relationship. Moreover, the threat of

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[12]Telser, 1980:27

termination may not be credible. If it is in the best interest of the wronged party to renew the contract in the following period, even after accounting for the possibility of future hold-up, the termination threat may not be viewed as credible by the potentially offending party.

Williamson (1983), in developing his "hostage model", examines self-enforcing agreements in an intermediate product market that involve "credible commitments". He considers an intermediate product that can be produced by one of two technologies: a "general purpose" technology or a "special purpose" technology. The latter involves investment in "transaction-specific" inputs and is more efficient at serving steady-state demands. Demand for the final product is assumed to be stochastic. There are two periods: orders are placed in the first, and production, if any, occurs in the second. If the special-purpose technology is adopted, the transaction-specific investment costs are incurred in period 1.

Efficiency considerations dictate that, for a given price of the intermediate input, the specific technology is employed if the total cost of production is less than that incurred with the general purpose technology. However, because there is some positive probability that the buyer will cancel the order after the supplier has incurred the specific investment cost, the supplier may find that the individually profit-maximizing strategy is to adopt the (jointly) inefficient general-purpose technology.

One way to avoid this market failure is for the supplier to make the specific asset investment and for the buyer to post a hostage; that is, the seller receives some form of advanced payment that is retained if the order is cancelled in the second period. The buyer's posting of a hostage of appropriate magnitude serves as a credible commitment to the supplier in that the possibility of *ex post* hold-up is eliminated. Although the order may be cancelled in the second period, it is now the buyer that incurs the cost of cancellation rather than the seller.

A "pure hostage" is that of general purchasing power. In the absence of "bounded rationality"[13] joined with "opportunism"[14], a security bond in the amount equal to the specific investment cost would yield an efficient contract. Williamson (1983) cites three possible ways in which the posting of a pure hostage may incite supplier opportunism: contrived cancellation; misrepresentation of specific investment costs; and expropriation of sellers through haggling at the contract negotiation stage.

In order to protect contracts against expropriation, the contractual relation may be expanded by devising a *mutual reliance relation*. That is, instead of posting a pure hostage, 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, the efficient exchange result will emerge.

Williamson maintains that the use of hostages to support exchange is widespread and economically important. It is not immediately obvious in many contractual relationships that a hostage is, in fact, an element of the contract. In many instances, the use of a hostage may be overshadowed by a complex governance structure that has arisen in response to expropriation hazards.

A number of industry studies explore the influence of transaction specific assets on contractual choice. Monteverde and Teece (1982a), in their study of auto components, found a positive and significant relationship between vertical integration and technical know-how. In a later article, Monteverde and Teece (1982b) found a positive relationship between the value of specialized tooling used in auto component manufacturing and the probability of quasi-integration. The existence of relationship-

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[13]Bounded rationality refers to individuals' inherent limitations of knowledge, foresight, skill and time (Simon, 1961). Comparative institutional choice decisions become relevant when the bounded rationality problem arises in the presence of uncertainty and/or complexity (Williamson, 1975:23).
[14]Opportunism refers to the pursuit of self-interest via strategic misrepresentation (Schelling, 1960; Goffman, 1969; Williamson, 1975).

specific human capital underlies the choice between internal and external sales representatives in Anderson and Schmettleins' study (1984) of the electronic components industry. In his study of aerospace procurement decision making, Masten (1984) found that the vast majority of investments in specialized tooling and test equipment were undertaken by the prime contractor.

The hypothesis that *ex ante* long-term contingent claims contracts are used to guard against *ex post* performance problems has been empirically supported by Joskow (1987). He examines the importance of specific relationship investments in determining the duration of coal contracts negotiated between coal suppliers and electrical utilities. The empirical results obtained indicate that, as relationship-specific investments become more important, the parties rely on longer-term contracts that specify the terms and conditions of repeated transactions *ex ante*, rather than relying on repeated bargaining.

This thesis posits that the structure of incomplete long-term contracts in the intermediate market for raw fish serves to circumvent the hold-up problem. In particular, the non-monetary compensation mechanisms observed to accompany long-term contracts play the role of Williamsonian hostages. The following chapter presents a general model of the hold-up problem. An application of this model to the intermediate market for raw fish is then presented.

CHAPTER 5: MODELLING THE HOLD-UP PROBLEM

The following simple illustration depicts the way in which the potential for *ex post* hold-up may present a contracting problem for the exchange of one unit of an intermediate product, X. Consider a potential transaction, T, between two parties. Denote the upstream supplier of the intermediate product by S and the downstream buyer of the intermediate product by B. The downstream buyer may be the producer of another intermediate product, or the producer of a final product. Assume, for illustrative simplicity, that the buyer transforms product X into a final product Y which is exchanged on the wholesale market.

In order to facilitate the transaction, T, both parties must undertake fixed **relation-specific** *ex ante* investments, the costs of which are I_S and I_B. That is, in stage 1 supplier S undertakes a discrete investment, I_S, which allows him/her to produce the intermediate product according to the specifications of buyer, B. Similarly, the buyer, anticipating delivery of this specialized intermediate product, undertakes a discrete investment, I_B, which serves to augment the value of the final product for the wholesale market. These investments are relation-specific in the sense that I_S and I_B represent investment costs in excess of those that would be undertaken in an alternative transaction. For simplicity, assume that variable costs of production are zero for both parties.

Exchange of the intermediate product takes place in stage 2, at which time the value of the final product on the wholesale market is also revealed. Let R_T denote the expected wholesale revenue generated by transaction T and R_A denote the wholesale revenue that the final product would generate in its next best alternative transaction.[1]

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[1] There are really two second-best alternatives here: one between supplier S and an alternative buyer, and one between buyer B and an alternative supplier. Let $R_A = MAX[R_A^S, R_A^B]$, where R_A^S is the expected wholesale renvenue to be generated in supplier S's next best alternative transaction, and R_A^B is the
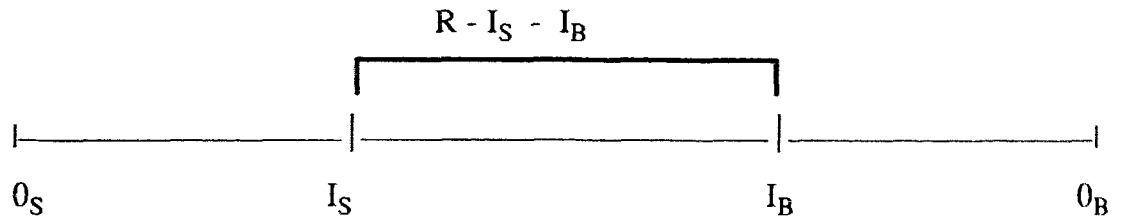
Assume that both parties hold the same expectations regarding the values of R_T and R_A. Together, therefore, the relation-specific investments are expected to yield a relation-specific gross wholesale revenue of $R = R_T - R_A$, to be realized at the end of stage 2. That is, R represents wholesale revenue in excess of that which could be generated from the most profitable alternative transaction. Thus, the relation-specific wholesale revenue, R, is the impetus for both parties to invest in relation-specific assets.

It is assumed that the objective of each party is to engage in a transaction that is expected to yield the highest private return. Thus, in stage 1, each party decides whether or not to undertake the relation-specific investment based on the expected private return from doing so. Given risk neutrality on the part of both parties, *ex ante* efficiency considerations dictate that the investments I_S and I_B should be undertaken if $R \geq I_S + I_B$.

In Figure 1, the gross expected relation-specific wholesale revenue, R, from the transaction is given by the distance $0_S 0_B$. *Ex ante* specific investment costs incurred by the supplier of the intermediate product are given by the distance $0_S I_S$, and those by the buyer, $0_B I_B$. Note again that these are not the total investments undertaken by the two parties, but only the value of the relationship-specific investments. Note also that the costs of these investments are inclusive of opportunity costs (i.e., the foregone benefits incurred by the next best alternative investment). Thus, the total rent from the transaction is then given by the distance $R - I_S - I_B$. As long as both parties anticipate an *ex post* return in excess of their initial investment costs, the transaction is one that results in (expected) gains from trade accruing to both the supplier and the wholesaler.

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expected wholesale revenue to be generate in buyer B's next best alternative transaction for the intermediate input.

Figure 1

$$R - I_S - I_B$$

$$|\underline{\hspace{3cm}}|\underline{\hspace{3cm}}|\underline{\hspace{3cm}}|$$

$$0_S \qquad\qquad I_S \qquad\qquad\qquad I_B \qquad\qquad 0_B$$

The *ex post* opportunity costs of the relation-specific investments are revealed in stage 2. The supplier's *ex post* opportunity cost of investment is equal to the maximum amount another wholesaler(s) is willing to pay for the intermediate product. The opportunity cost of the buyer's investment is equal to the *net* wholesale revenue that could be generated by purchasing the intermediate product from another supplier. Denote the *ex post* opportunity cost of the supplier's investment by L_S, and that of the wholesaler's investment by L_B. In stage 2, each party must decide whether or not to complete the exchange of the intermediate product under transaction T, or to engage in the next best alternative exchange. It is assumed that there is a cost to engaging in an alternative *ex post* exchange. Specifically, if a party reneges on an *ex ante* agreement, the possibility of future transactions between the original parties is eliminated. Thus, in deciding on whether or not to complete the transaction *ex post*, each party will weigh the current benefit from an alternative exchange (L_S or L_B) against the expected discounted value of future earnings that would be lost in the absence of future transactions between parties S and B.

Ex post efficiency (i.e., maximization of quasirent[2]) dictates that this transaction, T, between supplier, S, and buyer, B, be undertaken, rather than the next best alternative

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[2]"The quasi-rent value of the asset is the excess of its value over its . . . value in its next best *use* to another (user)." (Klein, Crawford and Alchian). In this application, the value of quasi-rent is given by: $QR = R - L_S - L_B$.

transaction, as long as $R \geq L_S + L_B$. That is, an *ex post* exchange between the parties

should occur if that exchange generates a larger quasirent than any alternative exchange.

The following discussion considers four possible *ex post* oucomes:

1. Each party's *ex post* opportunity cost exceeds their respective initial investment costs.

2. The supplier's *ex post* opportunity cost is less than his/her initial investment cost, while the buyer's *ex post* opportunity cost exceeds his/her initial investment cost.

3. The buyer's *ex post* opportunity cost is less than his/her initial investment cost, while the supplier's *ex post* opportunity cost exceeds his/her initial investment cost.

4. Both the buyer and the supplier incur initial specific investment costs that exceed their respective *ex post* opportunity costs.

1. *Ex Post Exchange in the Absence of Hold-Up*

Figure 2 illustrates a situation in which each party faces *ex post* opportunity costs

that exceed their initial investment costs. That is, $0_S I_S < 0_S L_S$ and $0_B I_B < 0_B L_B$. Both the

supplier and the buyer, in alternative transactions, are able to recover their initial specific

investment costs.[3] Note that, in the transaction illustrated in Figure 2, the supplier is

unwilling to accept *ex post* compensation for the intermediate product less than $0_S L_S$

while the buyer is unwilling, *ex post*, to pay compensation that would leave him/her with

less than $0_B L_B$. Since *ex post* gains from trade exist (i.e., $R - L_S - L_B > 0$), exchange

between parties S and B will occur, as efficiency dictates.

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[3] Note that although investments I_S and I_B are relation-specific, they are not necessarily worthless in an alternative *ex post* exchange (i.e., $L_S, L_B \geq 0$). The specificity of investments derives from the *ex ante* expectation that, $R > 0$ only if investments I_S and I_B are employed in transaction T. Moreover, investments I_S and I_B are relation-specific in an *ex post* sense as long as $R > L_S + L_B$.

Figure 2

$$R - I_S - I_B$$

$$0_S \quad\quad I_S \quad L_S \quad\quad\quad L_B \quad I_B \quad\quad 0_B$$
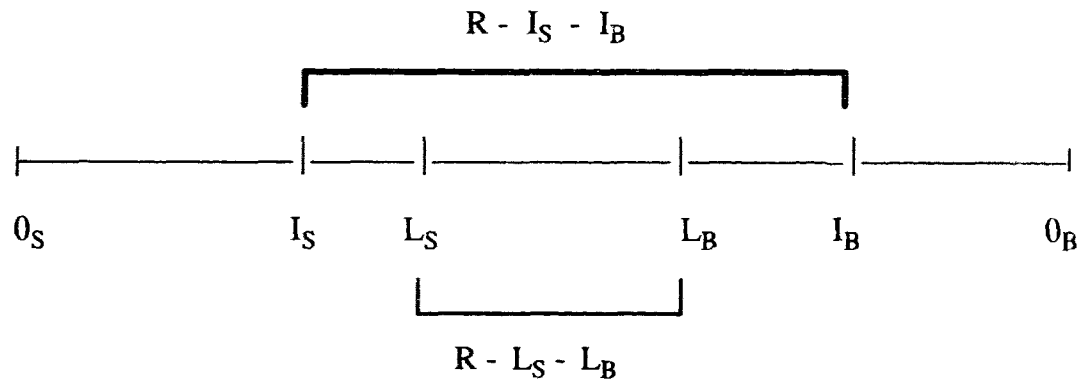
$$R - L_S - L_B$$

The quasi-rent from the transaction is identified as $R - L_S - L_B$, or as the distance $L_S L_B$ in Figure 2. Each party would like to extract for him/herself as much of the quasi-rent as possible. The actual division of the surplus depends upon the relative *ex post* bargaining strengths of the two parties. In any case, compensation to the supplier of the intermediate product will be somewhere between $0_S L_S$ and $0_B L_B$; the buyer will be left with the remainder, if any. Under these *ex post* circumstances, neither party has cause to regret having incurred the initial relation-specific investment costs. Thus if *ex ante* expectations are such that $0_S I_S < 0_S L_S$ and $0_B I_B < 0_B L_B$, both the buyer and supplier will have an incentive to undertake their respective *ex ante* invesments.

2. Downstream Hold-up

Figure 3 illustrates the circumstances under which the supplier is subject to potential hold-up by the buyer. The supplier's *ex post* opportunity cost of investment, L_S, is less than the *ex ante* relation-specific investment costs, I_S. That is, the supplier's next best alternative to selling to buyer B, is to sell to another wholesaler that would offer a

maximum of L_S for the intermediate product. The alternative *ex post* exchange would result in a net loss for the supplier. The wholesaler, B, on the other hand, is able to receive net revenue in the amount $0_B L_B$ if the initial investment is used to purchase and process the intermediate product produced by an alternative supplier. Thus, the buyer profits from undertaking the relation-specific *ex ante* investment, even in an alternative *ex post* exchange.

Since the *ex post* quasi-rent to this transaction is positive (i.e., $R - L_S - L_B > 0$), *ex post* exchange will take place, given initial investments. It is possible, however, that the transaction could result in a net loss to the supplier. Given that the wholesaler has knowledge of the supplier's "next-best" alternative, and that the wholesaler wishes to capture as much of the quasi-rent as possible, he/she may offer a price for the intermediate product that would not allow the supplier to recover the initial investment, $0_S I_S$. Although expected compensation in any amount less than $0_S I_S$ would have been unacceptable to the supplier prior to him/her undertaking the initial investment, the *ex post* absence of a more profitable alternative renders it in the best interest of the supplier to accept any compensation in excess of L_S. If the supplier holds the *ex ante* expectation that $0_S L_S < 0_S I_S$, he/she will recognize the potential for *ex post* hold-up and will be unwilling to incur the *ex ante* investment costs.

3. Upstream Hold-Up

Circumstances may also permit the supplier to hold-up the wholesaler. Suppose, for example, circumstances result in *ex post* opportunity costs that are relatively high for the supplier and low for the wholesaler, as depicted in Figure 4. If $0_S L_S > 0_S I_S$ and $0_B L_B < 0_B I_B$, the upstream firm has the opportunity to hold-up the wholesaler by demanding compensation greater than $(R - I_B)$. Given that *ex ante* investments have already been undertaken, and given the absence of a more profitable *ex post* alternative,

the wholesaler, albeit reluctant, will accept the terms of the transaction as long as he/she receives net revenues in excess of $0_B L_B$. Of course if the wholesaler *expects* to be held-up in the *ex post* exchange, he/she will be unwilling to incur the *ex ante* investment costs in stage 1.

Figure 3

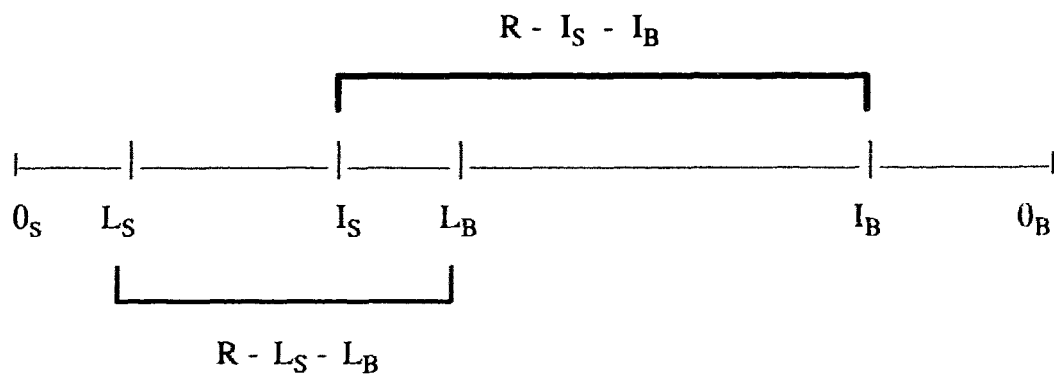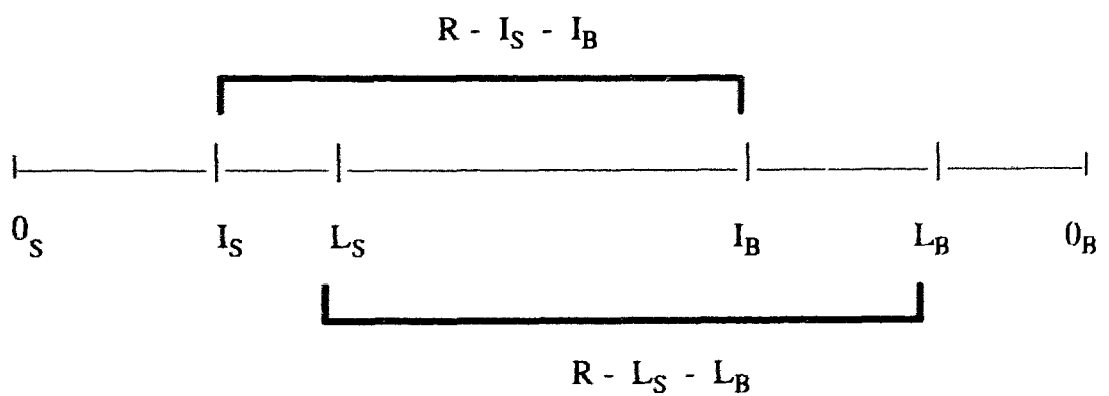$$R - I_S - I_B$$

$$R - L_S - L_B$$

$0_S \quad L_S \qquad\qquad I_S \quad L_B \qquad\qquad\qquad\qquad I_B \qquad 0_B$

Figure 4

$$R - I_S - I_B$$

$$R - L_S - L_B$$

$0_S \qquad\qquad I_S \quad L_S \qquad\qquad\qquad I_B \qquad L_B \qquad 0_B$

Figure 5 illustrates circumstances under which the *ex post* alternatives facing both parties are such that *ex ante* specific investments cannot be recovered by either party in an alternative *ex post* exchange. Given that each party expects the absence of profitable *ex post* alternatives, will the initial relation-specific investments be undertaken? This depends upon whether one of the parties expects to be held-up by the other party. The ability to behave opportunistically in an *ex post* exchange arises from the existence of *ex post* bargaining strength. Given symmetry of information, both *ex post* and *ex ante*, each party is aware that the other party has no profitable *ex post* alternatives and, therefore, no *ex post* bargaining strength. Thus, the potential for opportunistic behaviour does not exist. Since there are positive gains from trade, both *ex post* and *ex ante*, this transaction will occur as efficiency dictates.

Given the potential for either upstream or downstream hold-up, market failure occurs because potential gains from trade arising from *ex ante* relation-specific investments are unexploited. The potential victim refuses to undertake *ex ante* relation-specific investments because he/she expects that, given the opportunity, the other party will engage in *ex post* hold-up.

Figure 5

$$R - I_S - I_B$$

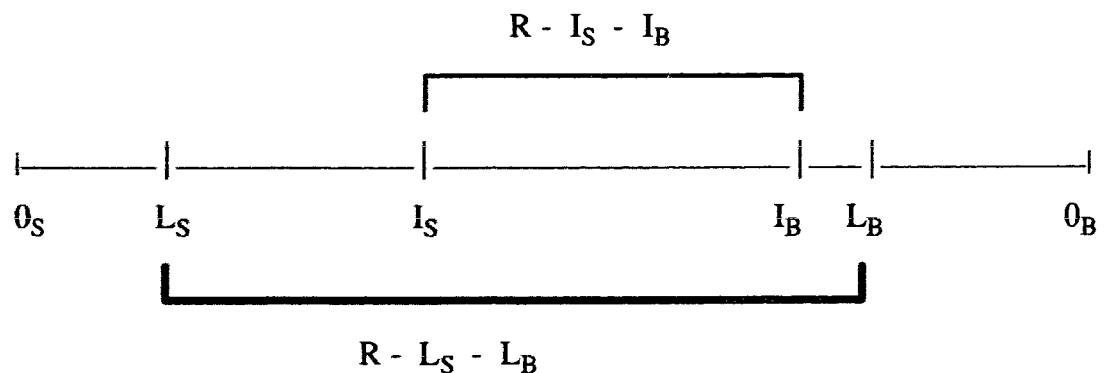|				
0_S	L_S	I_S	I_B L_B	0_B

$$R - L_S - L_B$$

Figure 6 replicates the situation presented in Figure 3, where the supplier is the potential victim of *ex post* hold-up. Under these circumstances, it is in the wholesaler's best interest to exchange with this supplier rather than another since the net wholesale revenue obtainable from this transaction exceeds that of the next best alternative, $0_B L_B$. If, for example, the division of rent was such that the wholesaler received the portion $0_B S_i$, and the supplier received the portion $0_S S_i$, both parties would do better than they could in an alternative transaction. The wholesaler's problem is to convince the supplier in period 1 that the intermediate price paid in period 2 will result in $0_S S_i \geq 0_S I_S$. Alternatively, if the wholesaler was the potential victim of hold-up, as illustrated in Figure 4, the supplier would find it desirable to convince the wholesaler that $0_B S_i \geq I_B$.

Figure 6

/———|—————|————|————|——————|——————————|

0_S L_S I_S S_i L_B I_B 0_B
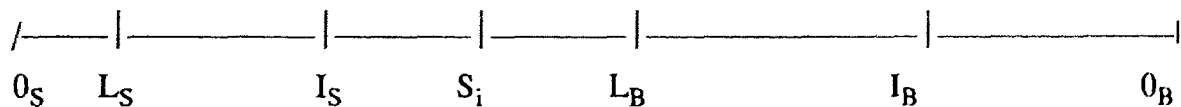
Williamson (1987) has observed that transactions that are potentially subject to hold-up are often supported by the potentially opportunistic party making an *ex ante* credible commitment to the exchange. The following simple model illustrates how an *ex ante* contractual agreement, accompanied by credible investments, serves to promote the efficient exchange of an intermediate product.

The Model

There are two risk-neutral economic agents: a buyer or wholesaler, B, and a supplier, S. At the beginning of the period, the wholesaler and supplier consider making relationship-specific investments in order to complete a transaction, T, of an intermediate product, X, at the end of the period. Denote these initial specific investments by I_S and I_B. Recall that these are not the total investments undertaken by the two parties, but only the value of the relationship-specific investments. Both economic agents wish to maximize the individual return to their respective *ex ante* specific investment.

Let R_i be the state-contingent *ex post* return to the transaction; that is, R_i is the market value of the output when the two specific investments, I_S and I_B, are combined, where state i occurs with probability p_i. Further, define *ex post* opportunity costs as follows: L_{Si} is the supplier's *ex post* opportunity cost of the initial specific investment, I_S, in state i; L_{Bi} is the buyer's *ex post* opportunity cost of the initial specific investment, I_B, in state i. The initial investments, I_S and I_B, are specific to the transaction if : $E(R_i) > E(L_{Si}) + E(L_{Bi})$; that is, the *ex post* quasi-rent is strictly positive. It is assumed that this specificity condition is satisfied throughout the analysis.

Recall that market failure resulting from the hold-up problem occurs if one of the parties fails to undertake an *ex ante* efficient relation-specific investment because he/she anticipates a net loss with the completion of the *ex post* exchange. That is, both parties want to avoid a situation in which *ex post* efficiency dictates that an exchange takes place. but in which the initial investment is regretted. The model proceeds as follows: 1. the conditions for *ex ante* efficiency are established; 2.the conditions for *ex post* contractual performance are established; 3. the conditions which lead to market failure are established; 4. an efficient contract which combats market failure is presented.

Ex Ante Efficiency

There are three conditions necessary in order for the initiial specific investments, I_S and I_B, to be undertaken: (1)the parties must hold the expectation that the gross collective return from the specific investments at least covers the sum invested; (2) the supplier expects to at least recover the costs of the intitial investment, I_S; (3) the buyer expects to at least recover the costs of the initial investment, I_B. These three conditions are represented by the following set of equations, where N_T denotes the net expected return from the transaction, N_S denotes the net expected return accruing to the supplier, and N_B denotes the net expected return accruing to the buyer.

$$N_T = E(R_i) - I_S - I_B \geq 0 \tag{1}$$

$$N_S = E(K_i) - I_S \geq 0 \tag{2}$$

$$N_B = E(W_i) - I_B \geq 0 \tag{3}$$

where K_i is defined as the state-specific return to the supplier's initial specific investment,[4] and $E(W_i) = E(R_i) - E(K_i)$. Equation (1) simply states that, of all possible transactions, transaction T is expected to generate the greatest total surplus. Equation (2) states that, in order to agree to the transaction, the supplier must expect to earn a return, $E(K_i)$, sufficient to recover the intial specific investment cost, I_S. Similarly, equation (3) states that the buyer will agree to the transaction if he/she expects to earn a return, $E(W_i)$, sufficient to recover the initial specific investment cost, I_B.

---

[4]Note that K_i is not the total return to the supplier's investment costs, but just the return arising from the existence of the specific intitial invesment costs, I_S.

Each party's expectation of net returns depends upon the possibility and direction of *ex post* hold-up. The potential for hold-up is, in turn, dependent upon the *ex post* contractual performance constraints faced by each party.

Ex Post Contractual Performance

We begin by establishing the conditions under which it is in both parties best interests to complete an *ex post* exchange, **given that *ex ante* investments have been made**. In deciding whether or not to complete the *ex post* exchange, each party must take into account the cost of violating the agreement reached in stage 1. Suppose that two parties establish an (implicit or explicit) contractual understanding and proceed to undertake relation-specific investments. In many trading relationships, failure to complete the transaction in stage 2 negates the possibility of future trade between these two parties. Thus, a party will renege on the *ex ante* agreement if the gain from doing so (i.e., the *ex post* opportunity cost) exceeds the cost of doing so (i.e., the loss of future net benefits from this trading relationship). It is assumed, for simplicity, that expected net benefits from future transactions between these two parties is equal to zero.

Given that state i obtains, the following conditions must be satisfied if an *ex post* exchange between these two parties is to be realized:

$$K_i \geq L_{Si} \tag{4}$$

$$W_i \geq L_{Bi} \tag{5}$$

Equation (4) is the seller's *ex post* performance constraint in state i: The return to the specific investment, K_i, must exceed the payoff possible in an alternative transaction, L_{Si}. Equation (5) is the wholesaler's performance constraint in state i: the net payoff from

the exchange this period, W_i, must exceed the *ex post* opportunity cost of the wholesaler's specific investment, L_{Bi}.

Thus, each party expects, *ex ante*, to receive, at a minimum, the following *ex post* returns:

$$\underline{K_i} = L_{Si}; \qquad \underline{W_i} = L_{Bi}$$

In addition, each party expects to receive some portion of the quasi-rent, $R_i - L_{Si} - L_{Bi}$. Symmetry of information implies that both parties are aware of their own and each other's *ex post* opportunity costs. If both parties are opportunistic, each will attempt to maximize their individual shares of the *ex post* quasi-rent. Given that the distribution of bargaining power is solely determined by relative *ex post* opportunity costs, then, *ex ante*, each party would expect to receive one-half of the *ex post* surplus in each state. We are now in a position to identify each party's *ex ante* expectation of *ex post* returns:

$$
\begin{aligned}
E(K_i) &= \Sigma p_i[\underline{K_i} + (R_i - L_{Si} - L_{Bi})/2] \\
&= \Sigma p_i[L_{Si} + (R_i - L_{Si} - L_{Bi})/2] \\
&= \Sigma p_i[(R_i + L_{Si} - L_{Bi})/2] \qquad (6)
\end{aligned}
$$

$$
\begin{aligned}
E(W_i) &= \Sigma p_i[\underline{W_i} + (R_i - L_{Si} - L_{Bi})/2] \\
&= \Sigma p_i[L_{Bi} + (R_i - L_{Si} - L_{Bi})/2] \\
&= \Sigma p_i[(R_i + L_{Bi} - L_{Si})/2] \qquad (7)
\end{aligned}
$$

Equation (6) defines the supplier's expected *ex post* return from the transaction: the supplier must receive at least $\underline{K_i} = L_{Si}$ in order to complete the *ex post* exchange; in addition, the supplier expects to extract one-half of the *ex post* quasi-rent. Similarly, the

buyer expects to receive his/her option value, L_{Bi}, plus one-half of the *ex post* quasi-rent, as indicated in equation (7).

Market Failure Conditions

Efficiency considerations dictate that the transaction between these two parties take place if *ex ante* expected net rents from this transaction and future transactions are non-negative. Market failure obtains if, given (1) (i.e., $N_T \geq 0$), either the supplier or the buyer does not expect to recover his/her initial investment costs from this transaction and future transactions. Formally, market failure results if:

Case (i): $N_T \geq 0$ **and** $N_S < 0$, **or**

$N_T \geq 0$ **and** $E(K_i) - I_S < 0$, **or**

$N_T \geq 0$ **and** $\Sigma p_i[(R_i + L_{Si} - L_{Bi})/2] < I_S$ $\qquad$ (8)

Case (ii): $N_T \geq 0$ **and** $N_B < 0$, **or**

$N_T \geq 0$ **and** $E(W_i) - I_B < 0$, **or**

$N_T \geq 0$ **and** $\Sigma p_i[(R_i + L_{Bi} - L_{Si})/2] < I_B$ $\qquad$ (9)

Does there exist a contract which promotes efficient exchange when one of the above situations presents itself? In Case (i), the potentially opportunistic party is the buyer. Since the transaction, T, generates at least as much rent as any alternative transaction (i.e., $N_T \geq 0$), it is in the supplier's best interest to convince the buyer that the latter **will not** be the victim of *ex post* hold-up. The converse is true if Case (ii) presents itself; the buyer has an incentive to convince the supplier that hold-up will not occur. The

following section presents a contract in which the potentially opportunistic party makes an *ex ante* credible committment to a non-opportunistic *ex post* exchange.

An Efficient Contract

Consider the following *ex ante* contract between the two parties: The buyer B agrees to pay the supplier S a state specific sum $K_i = \underline{K}_i$ for delivery of the intermediate product, and, in addition, takes ci G of the supplier's specific investment, I_S. The contract is efficient if the values of K_i and G are such that the *ex post* contractual performance is guaranteed **and** the incentive exists for both parties to make the *ex ante* investments. Formally, we need to find G such that:

$$E(K_i) + G - I_S \geq 0$$

$$\Sigma p_i[(R_i + L_{Si} - L_{Bi})/2] + G - I_S \geq 0$$

and:

$$E(W_i) - G - I_B \geq 0$$

$$\Sigma p_i[(R_i + L_{Bi} - L_{Si})/2] - G - I_B \geq 0$$

Thus,

$$I_S - E(K_i) \leq G \leq E(W_i) - I_B$$

or:

$$I_S - \Sigma p_i[(R_i + L_{Si} - L_{Bi})/2] \leq G \leq \Sigma p_i[(R_i + L_{Bi} - L_{Si})/2] - I_B$$

The viability assumption (i.e., $E(R_i) - I_S - I_B > 0$) ensures that such a G always exists.

Case (i)

If $G > 0$, then the buyer is paying part of the supplier's investment. That is, when the supplier is the potential victim of *ex post* hold-up, it is the supplier that requires an
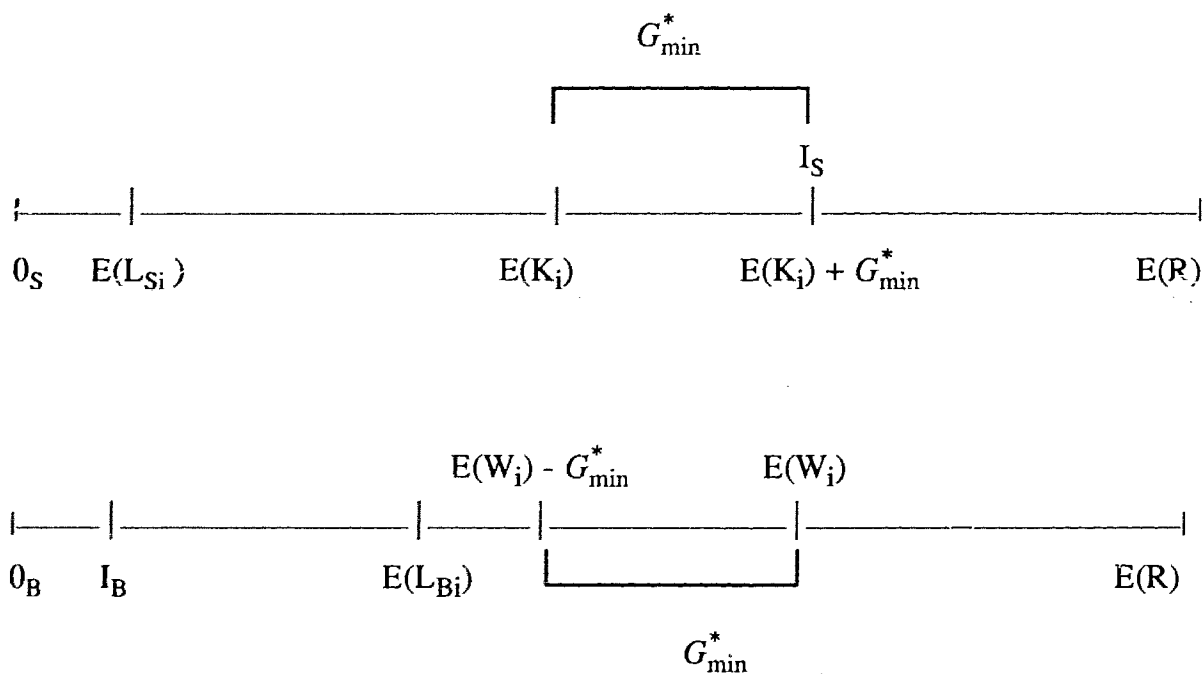
inducement to undertake the initial specific investment. In order to induce the supplier to partake in the transaction, the buyer must incur a minimum credible committment cost of $I_S - E(K_i)$; the maximum committment cost the buyer is willing to incur is given by $E(W_i) - I_B$.

Figure 7a illustrates such a contract when the supplier is the potential victim of *ex post* hold-up.. The distances $0_S E(R_i)$ and $0_B E(R_i)$ are identical in Figure 7a, as both parties hold the same expectation regarding the wholesale revenue from the sale of the final product. In the absence of an *ex ante* credible committment, the supplier's expected return is given by $E(K_i)$, a return that is insufficient to entice the supplier to undertake the initial investment cost, I_S. If the *ex ante* contract is accompanied by a payment, G^*_{min}, from the buyer to the supplier, the expected return is just sufficient to induce the supplier to undertake the investment, I_S.

The contract illustrated in Figure 7a defines the lower boundary of a range of contracts that promote efficient transactions when the supplier is the potential victim of *ex post* hold-up. It is a contract in which the supplier receives the lowest possible *ex post* compensation consistent with contractual performance in conjunction with the lowest possible *ex ante* credible commitment consistent with *ex ante* efficiency (i.e., $E(K) + G^*_{min} - I_S = 0$). The wholesaler extracts the entire expected rent from the transaction (i.e., $E(R) - E(\underline{K}) \cdot G^*_{min} - I_B = E(R) - I_S - I_B$. Thus, this contract can be thought of that which would obtain if the buyer had all of the *ex ante* bargaining power.

If the supplier had some *ex ante* bargaining power, he/she could negotiate a contract which allowed for a positive expected return to the specific investment, I_S. Note, however, that a higher state-specific compensation package is not credible. That is, although the buyer could *promise* to pay $K_i > \underline{K}_i$, it is not in his/her best interest to abide by this promise *ex post*, nor is it necessary to induce the supplier's *ex post* contractual performance. Thus, a positive expected return to the supplier can only be in the form of higher values of G^*.

$$G^*_{min}$$

$$I_S$$

0_S	$E(L_{Si})$	$E(K_i)$	$E(K_i) + G^*_{min}$	$E(R)$

$$E(W_i) - G^*_{min} \qquad E(W_i)$$

0_B	I_B	$E(L_{Bi})$		$E(R)$

$$G^*_{min}$$

What is the maximum credible commitment the buyer is willing to undertake in order to induce the supplier to undertake the initial investment I_B? The maximum value of G, G^*_{max}, is that for which the buyer's *ex ante* expected return is zero:

$$G^*_{max} = E(W_i) - I_B$$

This contract in which the minimum state-specific compensation but maximum credible commitment to the supplier obtains is illustrated in Figure 7b.

The above analysis indicates that when the supplier is the potential victim of hold-up, a contract in which the buyer makes an *ex ante* credible commitment, $G^*_{min} \leq G^* \leq G^*_{max}$, serves to promote efficient transactions.

Figure 7b
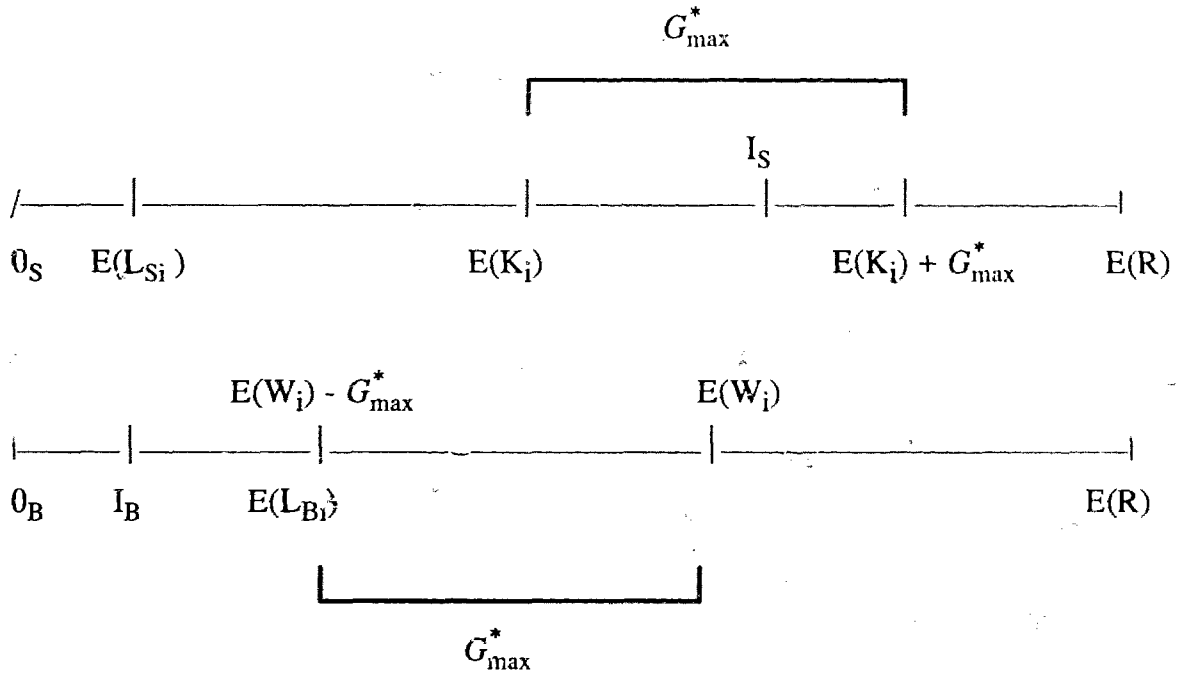
Case (ii)

It is also possible that it is the buyer/wholesaler that is the potential victim of hold-up. Under these circumstances, equilibrium values of G will be negative; that is, the supplier will partially assume the buyer's initial investment costs. The following contract ensures efficient exchange when equation (9) is not satisfied:

$$\hat{K}_i = L_{Si}$$

$$\hat{G}_{min} = I_B - E(W_i)$$

Again, this is a contract which offers the supplier the minimum state-specific compensation package, $\hat{K}_i = \underline{K}_i = L_{Si}$. *Ex ante* however, the supplier must incur a minimum credible committment cost of $\hat{G}_{min}$ in order to induce the buyer to partake in

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the transaction. This contract can be thought of as that which would obtain if the supplier had all of the *ex ante* bargaining power. If the buyer had some *ex ante* bargaining power, he/she could negotiate a contract which allowed for a positive return to the specific investment, I_B. The above contract is illustrated in Figure 8a. Note that the supplier earns a positive expected rent (i.e., $E(K_i) - I_S - \hat{G}_{min} > 0$) while a zero expected rent accrues to the buyer (i.e., $E(W_i) - I_B + \hat{G}_{min} = 0$).

What is the maximum credible commitment the supplier is willing to undertake in order to induce the buyer to undertake the initial investment I_B? The maximum value of G. $\hat{G}_{max}$, is that for which the supplier's *ex ante* expected return is zero:

$$E(K_i) - \hat{G}_{max} - I_S = 0$$

Such a contract is illustrated in Figure 8b.

Figure 8a

Figure 8b

$E(K_i) - \hat{G}_{max}$ $E(K_i)$

0s I_S $E(L_{Si})$ $E(R)$

$\hat{G}_{max}$

$\hat{G}_{max}$

I_B

0_B $E(L_{Bi})$ $E(W_i)$ $E(W_i) + \hat{G}_{max}$ $E(R)$
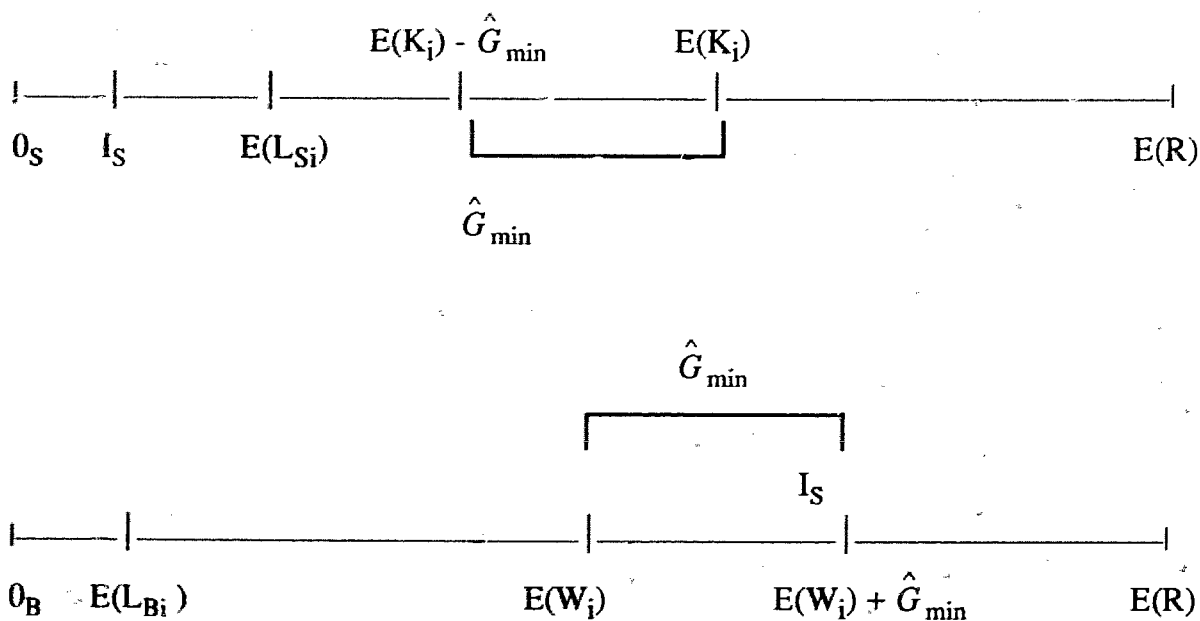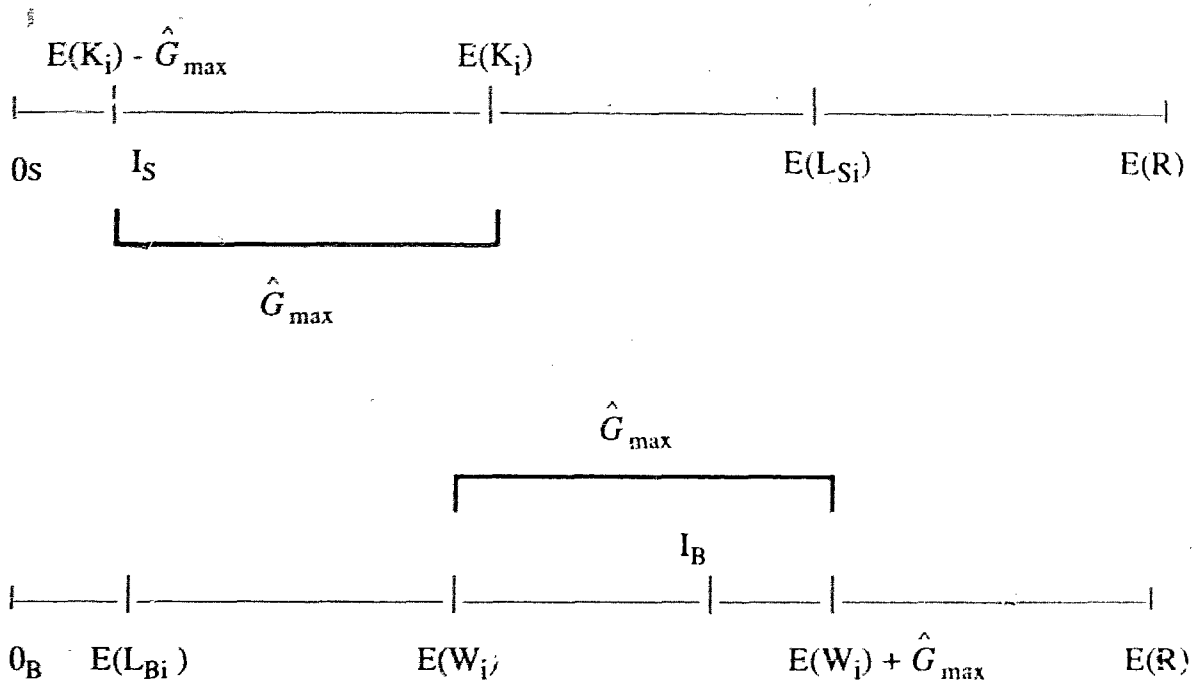
Thus, when the buyer is the potential victim of hold-up, a contract in which the supplier makes an *ex ante* credible commitment, $\hat{G}_{min} \leq \hat{G} \leq \hat{G}_{max}$, serves to promote efficient transactions.

B. Applying the Hold-Up Model to the B.C. Intermediate Market for Raw Fish

How does the above model explain contractual structure and contractual choice in the B.C. intermediate market for raw fish? Consider a potential transaction, T, between a fisher (S) and a wholesaler (B) that generates a total return in excess or either party's next best alternative. Suppose the fishe's initial seasonal investment, I_S, is **specific** to this particular transaction; then the *ex post* opportunity cost of that investment, L_S, will be less than the size of the initial investment itself. For example,

suppose a salmon seiner undertakes a large initial investment prior to exchange; part of this investment is highly specific to a small group of processors. In particular, the attributes of the target species and the nature of the gear results in a catch configuration that is valuable to canners, but not as valuable to the fresh/frozen processors.

Ex ante, the fisher will not expect *ex post* compensation in excess of one-half of the quasi-rent. If the fisher's expected *ex post* compensation, $E(K)$ is less than his/her initial investment costs, the fisher will not be willing to undertake this highly specific investment, I_S, unless the canner, B, credibly commits to the transaction. The credible committment, G^*, takes the form of *ex ante* non-monetary compensation. As noted previously, such compensation includes a variety of non-price services (egs., vessel maintenance and repair, moorage, nets and lofts, packing and collection, etc.) as well as the provision of vessel financing, and/or even the provision of the vessel itself.

The season-end bonuses that are observed to accompany long-term contracts are captured by the variable K_i in the above model. Recall that K_i is defined as the state-contingent return to the supplier's specific investment in the transaction. There is a temporal aspect to the bonus system that the model presented in this thesis does not capture. For the purpose of simplification, a transaction between a supplier and a buyer has been modelled as a one-shot exchange or delivery of fish. In fact, many transactions between two parties involve a succession of deliveries. The bonus is paid at the end of the season subsequent to the completion of all deliveries.

The hold-up model presented in this chapter allows for both upstream and downstream hold-up. In the case of potential upstream hold-up, the processor, B, credibly commits to the exchange by undertaking $\$G^*$ of the fisher's initial specific investment, I_S. In the case of potential downstream hold-up, however, it is the supplier that would be required to credibly commit to the transaction by undertaking $\$\hat{G}$ of the buyer's initial specific investment I_B. We do not observe such behaviour in the B.C. intermediate market for raw fish. That is, fishers do not undertake investments for the

purpose of credibly committing to exchange with a processor. The model indicates that such investments would be necessary in order to avoid the market failure that would result if the processor's initial investment had a very low value in an alternative *ex post* exchange. Thus, it must be the case that, relative to fishers' *ex ante* investments, processors' investments involve a lower degree of specificity to a particular transaction. This is indeed the case. Although canners do undertake an investment in a processing technology that is quite specific to the intermediate product produced by salmon seiners, there were, in 1988, 549 vessels supplying this product. Conversely, only 13 establishments were licensed to operate a commercial salmon cannery in 1988. Thus, the salmon seiner's initial investment is specific to a very small number of processors; thus, it is also much more specific to a particular transaction.

The potential for hold-up exists only in the presence of transaction-specific assets. Both harvesting and processing technologies in the intermediate market for raw fish exhibit varying degrees of specificity. A salmon-seine harvesting technology, for example, is specific to schooling species and results in a catch-configuration such that the majority of the harvest is suitable only for the canned market. Similarly, the canning technology requires inputs that cannot be redeployed to process species other than salmon. On the other hand, the salmon trolling harvesting technique may be employed in the capture of both schooling and non-schooling species, and produces a catch-configuration that is suitable to a number of final product forms. Similarly, the employment of a freezing technology in the harvesting sector allows the wholesaler flexibility across other fish species. Thus, salmon trolling involves a lower degree of asset specificity than does salmon seining, as does the production of a frozen final product relative to a canned final product. Therefore, salmon trollers and wholesalers operating in the fresh/frozen market should be more likely to operate on the spot market than to engage in transactions governed by incomplete, long-term contracts.

This application of the hold-up problem differs somewhat from the way hold-up has been previously illustrated in the literature. The potential for hold-up has been perceived to exist in circumstances where one agent's investment is specific to a **single** buyer or seller; that is, when there exists no alternative exchange. Although there are 13 canners operating in the B.C. intermediate market for fish, it is not the case that a vessel has 13 equally accessible alternative *ex post* exchanges. Some harvesting activity takes place in remote areas served only by one processor. Given positive transportation costs and the high perishability of the intermediate product, such a processor effectively has monopsony power.

This study, however, introduces the notion that the potential for hold-up may also exist in markets where investments are specific to multiple buyers and/or sellers. Even where two or more canners operate within close proximity of each other, the seller's alternatives are limited by the fact that these canners face capacity constraints. In years where harvests are low, processors will operate at below capacity and fishers may then face several alternative exchanges; i.e., there would be no hold-up problem. However, in seasons where the total harvest of fish is large, the capacity constraint on each processor may be binding. If a fisher has incurred investment costs that are specific to a small number of processors, he/she potentially faces *ex post* hold-up.

Are the empirical regularities in this industry consistent with the above theory? The following empirical analysis indicates a strong correlation between the incidence of non-price compensation and the degree of asset specificity in transactions. This correlation supports the hypothesis that contractual arrangements in the intermediate market for raw fish are chosen so as to minimize the transactions costs arising from the possibility of post-contractual opportunistic hold-up.

CHAPTER 6: EMPIRICAL METHODOLOGY

The purpose of the empirical analysis is to examine the way in which the nature of the contract varies across product and technological characteristics in both the harvesting and processing sectors. This is accomplished by analyzing individual transactions between fishers and processors. The hypothesis of the thesis is supported if there exists a (significantly) positive relationship between the degree of asset-specificity in transactions and the incidence of vertical ties (i.e., incomplete long-term contracting) between processors and fishers.

A transaction is defined as the delivery of a load of a particular species and product-form from one vessel to one processor, as recorded on a sales slip. A particular transaction is characterized as taking place under a long-term, incomplete contract if at least one of the following criteria are met:

1. the vessel owner/operator received a season-end bonus from the buyer/processor;

2. the vessel is fully or partially owned by the processor;

3. the vessel is fully or partially financed by the processor, but not owned by the processor.

It is important to note that other non-price compensation mechanisms (e.g., processor-provision of moorage, storage space, vessel maintenance) are also indicative of a long-term contractual relationship. Unfortunately, information on these variables is unavailable.

In order to determine the way in which the observed non-price compensation mechanisms vary across other attributes of the transaction, a stratified random sample[1] of transactions has been generated from the 1988 fishing season. The sample consists of 15,753 transactions between 726 vessels and 75 buyers. For each of the vessels, the identity of the owner(s) and creditor(s) (if any) are known; it is also known whether or not the vessel received a season-end bonus. 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; the processor financed the vessel; the vessel received a season-end bonus[2]; or there were no observable vertical ties that characterized the transaction.

The sample represents a cross-section of vessels and processors operating in at least one of the following fisheries: salmon (which includes 5 different species), herring, halibut, and sablefish (black cod). The attributes of the intermediate product vary both across and within these fisheries, as do the harvesting and processing technologies.

A. Measuring Asset Specificity

As noted previously, asset-specificity in the harvesting sector derives from the following sources: high perishability of the intermediate product and the inflexibility of

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[1]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 obervations 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.

[2]The 1988 Cost and Earnings Survey was boycotted by vessel owner/operators with strong processor affiliations; thus, all vessels receiving bonuses in the sample are neither owned nor financed by processors. This renders the above categories of long-term contracts mutually exclusive.

the harvesting technology employed in the transaction. Asset-specificity in the processing sector derives from the inflexibility of the processing technology.

Perishability

The effects of perishability are partially captured by both the identification of the species delivered in each transaction, as well as the form in which it is delivered. On average, herring can be held for a maximum of 1 to 2 days after capture and prior to delivery, salmon for 3 to 4 days, sablefish for 5 to 7 days, and halibut 1-2 weeks. Note that the perishability rankings given above hold for a given delivered product-form, specifically, fish delivered "in the round"[3]. The effects of perishability can be attenuated by on-board dressing (gutting and heading) and freezing.

Flexibility of the Harvesting Technology

There are three ways in which flexibility of the harvesting technology is important: flexibility across fisheries/species, flexibility across intermediate product-form, and flexibility across final product form.

A. Flexibility Across Fisheries/Species

The flexibility of the harvesting technology across fisheries is partially captured by the number of fishery-specific commercial harvesting licences attached to the vessel. That is, a vessel licensed to operate in only one fishery is considered a more specific investment than one licensed to fish in several fisheries.

Identification of the gear-type employed in the transaction also captures flexibility across fisheries and/or species. Five main gear-types are employed in the four fisheries under consideration: purse-seine, gillnet and troll gear are employed in the salmon

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

fishery; purse-seine and gillnet gear are employed in the herring fishery; longline gear is employed in the halibut fishery; and longline and trap gear are employed in the sablefish fishery. In general, net gear is the least flexible across fisheries and species because it is designed to target schooling species of fish (pink, chum, sockeye and herring). Note also that the salmon purse-seiners and gillnetters are specific to the salmon fishery and the herring purse-seiners and gillnetters are specific to the herring fishery. That is, the nets are not used interchangeably across these fisheries. Longline gear is more flexible than trap gear as the former is employed in both the halibut and sablefish fisheries, while trap gear is specific to sablefish. Troll gear is employed in the salmon fishery and tends to target chinook and coho, although it is at least as efficient (in terms of catch per unit of effort) at harvesting the schooling species of salmon.

B. Flexibility Across Delivered Product-Form

Flexibility across delivered product-form is captured by specifying the volume of catch delivered per transaction. Gear-types that generate large volumes of catch per delivery are relatively inflexible across delivered product-form. Purse-seine gear, for example, results in such large volumes of salmon or herring that any type of on-board processing is extremely difficult; consequently most transactions for which seine gear was employed consist of fish delivered in the round. Fishers using salmon troll gear, however, are able to accomplish some on-board processing.

C. Flexibility Across Final Product-Form

Recall that raw salmon is directed primarily toward either the canned or fresh/frozen markets; halibut and sablefish to the fresh/frozen markets; and herring primarily to the herring roe market. Salmon caught with purse-seine gear is generally

most appropriate for the canned market. This is partly due to the nature of the species themselves, and also because the fish is frequently marked and bruised by the net. Gillnetters are able to exert more control over the quality of the intermediate product than are purse-seiners, and serve both the canned and fresh/frozen markets. Troll-caught salmon could be directed toward either the canned or fresh/frozen market, although it receives a higher price on the fresh/frozen market. The importance of suitability of the intermediate product to final product-form derives from the number of potential buyers available to a particular fisher. In 1988, thirteen establishments were licensed to operate a commercial salmon cannery, while 126 cold storage facilities were issued processing licences. There were 35 firms licensed to process roe herring.

It is difficult to arrive at a general specificity ranking that embodies all the gear-types under consideration. Among the salmon gear-types, purse-seine gear is the most specific, and troll gear the least. Similarly, trap gear can be ranked as more specific than longline gear.

Flexibility of the Processing Technology

As discussed previously, the canning technology involves investments which are highly specific to producing canned salmon. The same is true for investment in the brining inputs required to produce roe herring, although the size of the investment is much lower than that for canning equipment/facilities. On the other hand, investments undertaken to process fresh/frozen fish are not specific to a particular species, or even to fish itself (eg., freezer space could be allocated to the production of fruit and/or vegetables). In order to account for asset specificity in processing, the buyer involved in each salmon transaction is identified as either a processor with canning facilities, or one without canning facilities.

B. Empirical Testing

Both parametric and non-parametric tests have been conducted in order to explore the validity of the thesis' hypothesis. Non-parametric tests are distribution-free and require no assumptions regarding the precise form of the sampled population. However, parametric statistical tests are more powerful than nonparametric tests, in the sense that the probability of making a Type II error[4] is lower (Downie and Heath, 1974: 260). The nonparametric test used in this analysis is the chi-square test; the parametric test involves deriving the maximum-likelihood estimates of a probit model.

Chi-Square Analysis

The chi-square test of independence is the non-parametric test used to explore the significance of the explanatory variables (Downie and Heath, 1974). Let us first determine whether or not there is significant variation of contractual choice across fisheries. Define the null hypothesis as:

H_0 : Contractual choice is independent of the fishery, or

$$p_i^L = p_j^L = p^L, \text{ or}$$

$$\frac{f_i^L}{N} = \frac{f_j^L}{N} = \frac{f^L}{N}.$$

where p_i^L is the probability of observing a long-term contract in fishery i, p_j^L is the probability of observing a long-term contract in fishery j, and p^L is the probability of observing a long-term contract, irrespective of the fishery. Similarly, f_i^L is the number of transactions governed by long-term contracts in fishery i, f_j^L is the number of

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[4]A Type II error occurs with the failure to reject the null hypoyhesis when it should be rejected.

transactions governed by long-term contracts in fishery j, and f^L is the total number of transactions governed by long-term contracts. It is useful to summarize observed frequencies of transactions across fisheries in a contingency table.

CONTINGENCY TABLE #1					
OBSERVED FREQUENCIES					
	Salmon	Herring	Halibut	Sablefish	Total
Long-Term Contract	8242	174	55	177	8648
Spot-Market Contract	6621	110	211	163	7105
Total	14863	284	266	340	15753

	EXPECTED FREQUENCIES			
	Salmon	Herring	Halibut	Sablefish
Long-Term Contract	8159.41	155.91	146.03	186.65
Spot-Market Contract	6703.59	128.09	119.97	153.35

The sample consists of 15,753 transactions. The transactions governed by a long-term contract number 8,648. That is, these are transactions in which the processor had full or partial ownership in the vessel, financed the vessel, or compensated the fisher with a season-end bonus. A spot-market arrangement governed 7,105 transactions. Of the 14,863 salmon deliveries, 8,242 were conducted under an incomplete, long-term

contract, and 6,621 were exchanged on the spot-market. Similarly, of the 266 halibut deliveries, 211 were conducted on the spot market, and 55 via a long-term contract.

Given the null hypothesis, expected frequencies for each cell of the contingency table can be generated. The expected frequency for cell 1,1 (i.e., the cell in row 1 and column 1) is computed as follows:

$$f_{1,1}^e = \frac{\sum_{r,1} f^o \sum_{1,c} f^o}{\sum_{r,c} f^o}$$

where r denotes the row. c denotes the column, $\sum_{r,1} f^o$ is the total number of transactions observed in the salmon fishery, $\sum_{1,c} f^o$ is the total number of transactions observed to be governed by a long-term contract, and $\sum_{r,c} f^o$ is the total number of transactions.

Expected frequencies for the other cells are similarly computed. Thus, expected frequencies are simply the number of observations we would expect in each category, given that contractual choice is independent of the fishery in which the transaction takes place.

The chi-square statistic of independence is used to determine whether expected frequencies deviate significantly from observed frequencies. The computed chi-square statistic is given by:

$$\chi^2 = \sum_{r,c} (f^o - f^e)^2 / f^e$$

The computed chi-square for the above contingency table is $\chi_c^2 = 133.42$.

The critical chi-square value for $(r - 1)(c - 1)$[5] = 3 degrees of freedom, and for a level of significance, $\alpha = .01$, is $\chi^2 = 11.3449$. That is, the probability that the computed chi-square statistic exceeds the critical value of 11.3449 is equal to .01. Thus, the null hypothesis that contractual choice is independent of the fishery is easily rejected.

In order to observe the way in which observed frequencies deviate from expected frequencies, the value $\Psi_{r,c} = (f^0 - f^e)/f^e$ has been plotted in a bar-graph in Figure 6-1. Of particular interest here is the direction of this deviation. A positive value of $\Psi_{r,c}$ implies that, for a given classification of contractual arrangement and species, there are a greater number of transactions than expected under the null hypothesis. The data below indicates that $\Psi_{r,c} > 0$ for transactions governed by long-term contracts in the salmon and herring fisheries. Conversely, in the sablefish and halibut fisheries, there is a greater occurrence of spot-market contracts than expected under the null hypothesis.

In order for the thesis' hypothesis to be consistent with these values for $\Psi_{r,c}$, the degree of asset specificity should be highest in the herring fishery followed by the salmon fishery, then the sablefish fishery, and lowest in the halibut fishery. Recall those characteristics that contribute to asset-specifity in the transaction: perishability of the intermediate product; flexibility of the harvesting technology across species, intermediate product-form and final product-form; and flexibility of the processing technology across intermediate and final product-form.

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[5] r denotes the number of rows in the contingency table, and c denotes the number of columns

(OBSERVED-EXPECTED)/EXPECTED

	Herring	Salmon	Sablefish	Halibut
Long-Term Contract	0.12	0.01	-0.05	-0.62
Spot-Market Contract	-0.14	-0.01	0.06	0.76

FIGURE 6-1

CONTRACTUAL CHOICE ACROSS FISHERIES
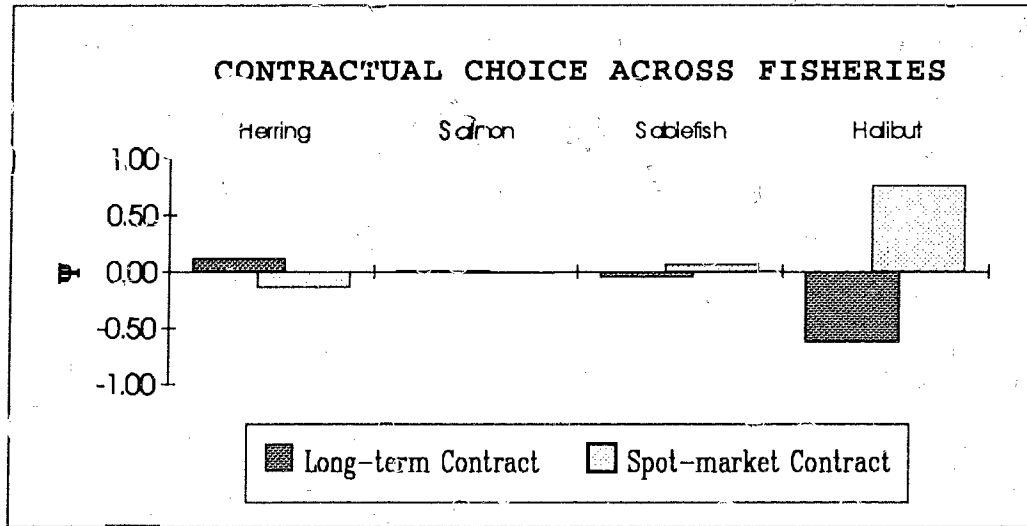
The above ranking for $\Psi_{r,c}$ is identical to the previously defined perishability ranking. Moreover, the specificity ranking across gear-types also supports the above values for $\Psi_{r,c}$. Herring fishers rely very heavily on the most inflexible harvesting technology (i.e., purse seining); some salmon fishers also employ this inflexible harvesting technology but others use a highly flexible gear-type (troll gear). The long-line gear employed in the halibut fishery is also identified as flexible across species and final product-form. Finally specificity in the processing technology is also consistent with the above ranking. Recall that the bulk of raw herring is directed to the market for herring roe. Investments in the processing of herring roe are not adaptable to other species or product-forms. Similarly, a large proportion of salmon is directed toward the canned market, a product-form that also involves specific investments. Sablefish and

halibut, however, are directed toward the fresh/frozen market, which involve very flexible processing technologies.

The above chi-square test does not capture the effects of the above variables individually. That is, the contribution of perishability to contractual choice cannot be distinguished from those of technological inflexibility in harvesting or processing. The cross-section of fisheries involved in this study does not allow this observational equivalence issue to be completely resolved. That is, there is not enough variation in all variables across or within these four fisheries in order to determine their independent influence on contractual choice. Nonetheless, strong empirical support for the above variables is obtained by applying the chi-square analysis to different subsets of the data.

Perishability

Recall that the perishability of a fisher's catch can be alleviated by on-board dressing and/or freezing. A chi-square test of the significance of delivered product-form to observed contractual choice is conducted below. Contingency Table #2 indicates that, of the 15,753 transactions, 11,588 consisted of fish delivered in the round (fresh and undressed), 3,808 consisted of a fresh-dressed intermediate product, and 357 consisted of fish that had been frozen on-board prior to delivery. The majority of round deliveries (7,282) were exchanged under a long-term contract, while the majority of dressed (2,525) and frozen (274) deliveries were exchanged on the spot-market. The expected frequencies of transactions in each classification are also shown in Contingency Table #2 along with the computed and critical chi-square values. Note that the null hypothesis is easily rejected at the .01 level of significance.

CONTINGENCY TABLE #2				
OBSERVED FREQUENCIES				
	Round	Dressed	Frozen	Total
Long-Term Contract	7282	1323	83	8648
Spot-Market Contract	4306	2525	274	7105
Total	11588	3808	357	15753
EXPECTED FREQUENCIES				
	Round	Dressed	Frozen	
Long-Term Contract	6361.52	2090.50	195.98	
Spot-Market Contract	5226.48	1717.50	161.02	

COMPUTED CHI-SQUARE = 1101.14   CRITICAL CHI-SQUARE (2, .01) = 9.2

The deviations of observed from expected frequencies, $\Psi_{r,c}$ are recorded below and illustrated in Figure 6-2.

(OBSERVED-EXPECTED)/EXPECTED			
	Round	Dressed	Frozen
Long-Term Contract	0.14	-0.37	-0.58
Spot-Market Contract	-0.18	0.47	0.70

The deviation of observed frequency from that expected under the null hypothesis is positive for transactions involving fish delivered in the round and negative for fish delivered in the dressed or frozen product-forms. Given that delivered product-form is an accurate proxy for perishability, these results are consistent with the paper's identification of the perishability variable as a determinant of contractual choice.

FIGURE 6-2

CONTRACTUAL CHOICE ACROSS DELIVERED PRODUCT-FORM
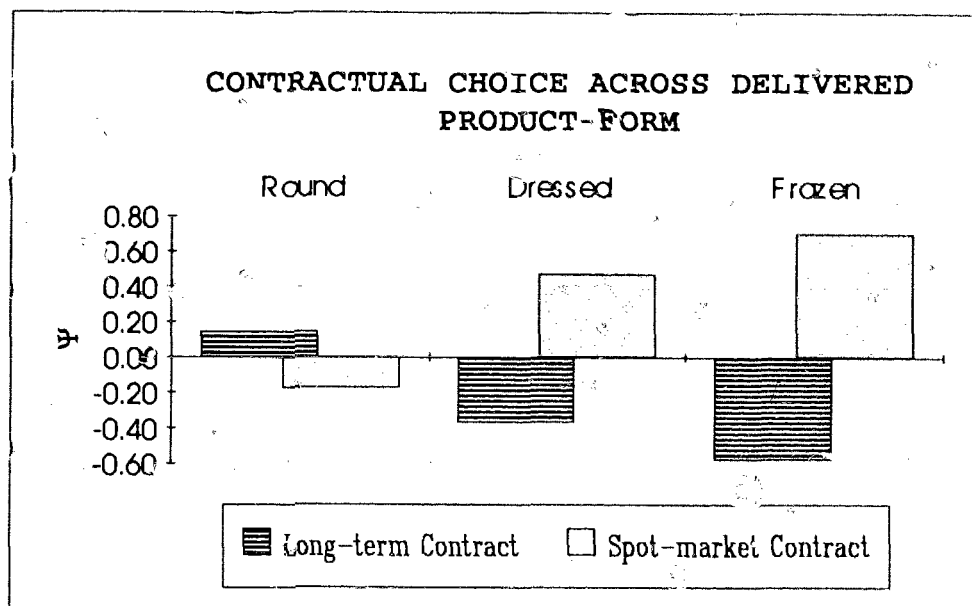
Note that the above chi-square test does not allow us to definitively identify perishability as an important determinant of contractual choice. This is because delivered product-form is correlated with other variables that are proposed to determine contractual choice. Contingency tables 2a to 2i illustrate the observed frequencies of transactions across delivered product-form, when all other variables that potentially affect contractual choice are held constant. In particular, for each of the chi-square tests, 2a to 2i, the following variables are held constant: species[6], gear-type and number of licences attached to the vessel. The way in which contractual choice varies across delivered product form is then analyzed.

All 3,750 transactions referred to in contingency table 2a were conducted by salmon seiners with only one licence. Of these transactions, 3,507 consisted of fish delivered in the round and 243 consisted of a fresh-dressed intermediate product. Note

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[6]There is only one delivered product-form for all species but salmon. Thus, the observations in contingency tables 2a-2i consist of salmon transactions only.

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that the computed chi-square is significant at the .001 level of significance. Moreover, the deviation of observed from expected frequency, Ψ, is positive for round deliveries and negative for dressed deliveries. Contingency table 2b refers to transactions conducted by salmon seiners with two licences, while Table 2c consists of transactions conducted by salmon seiners with three or more licences. Each of these tests indicates that delivered product-form is a significant determinant of contractual choice for transactions involving salmon seine gear.

Contingency tables 2d to 2f refer to transactions involving salmon gillnetters. Table 2d illustrates the distribution of transactions across contractual choice and delivered product-form for vessels with one licence, Table 2e for vessels with two licences, and Table 2f for vessels with three or more licences. The chi-square analyses indicate that delivered product-form is an important determinant of contractual choice for gillnetters with one licence ($\alpha = .10$). However, the computed chi-square statistic is insignificant in tests 2e and 2f. That is, for transactions involving multiple-licensed gillnetters, delivered product-form does not appear to be an important determinant of contractual choice.

CONTINGENCY TABLE #2a			
Salmon Seiners; One Licence			
OBSERVED FREQUENCIES			
	Round	Dressed	Total
Long-Term Contract	2804	136	2940
SpotMarketContract	703	107	810
Total	3507	243	3750
COMPUTED CHISQUARE	= 77.22		$\alpha = .001$
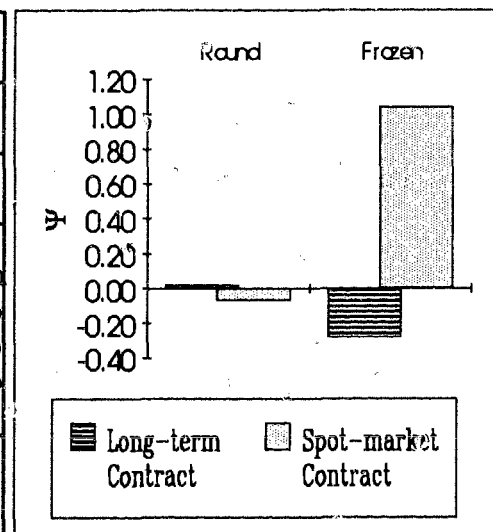
CONTINGENCY TABLE #2b

Salmon Seiners; Two Licences

OBSERVED FREQUENCIES

	Round	Dressed	Total
Long-Term Contract	2161	172	2333
Spot Market Contract	193	55	246
Total	2354	227	2581

COMPUTED CHISQUARE	=	61.25	$\alpha = .001$
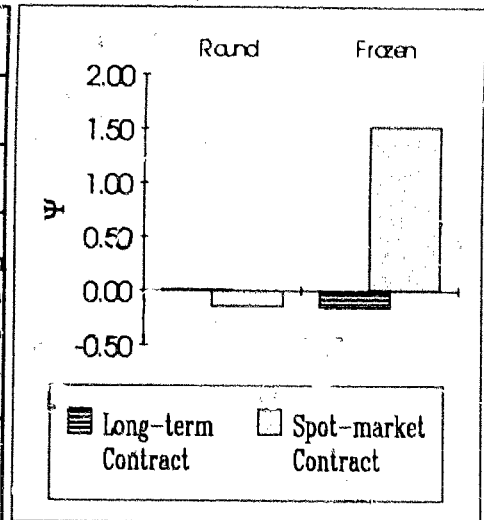
CONTINGENCY TABLE #2c

Salmon Seiners; Three or More Licences

OBSERVED FREQUENCIES

	Round	Dressed	Total
Long-Term Contract	708	131	839
Spot Market Contract	276	79	355
Total	984	210	1194

COMPUTED CHISQUARE	=	7.59	$\alpha = .01$
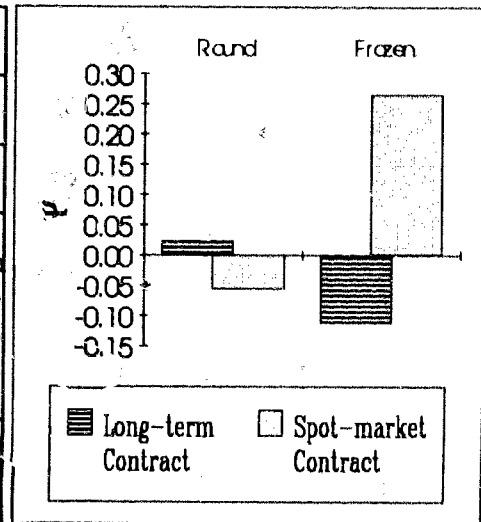
CONTINGENCY TABLE #2d

Salmon Gillnetters; One Licence

OBSERVED FREQUENCIES

	Round	Dressed	Total
Long-Term Contract	1005	105	1110
Spot Market Contract	1571	206	1777
Total	2576	311	2887

COMPUTED CHISQUARE	=	3.23	$\alpha = .10$

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CONTINGENCY TABLE #2e

Salmon Gillnetters; Two Licences

OBSERVED FREQUENCIES

	Round	Dressed	Total
Long-Term Contract	252	37	289
Spot Market Contract	921	149	1070
Total	1173	186	1359

COMPUTED CHISQUARE	=	0.243	insignificant
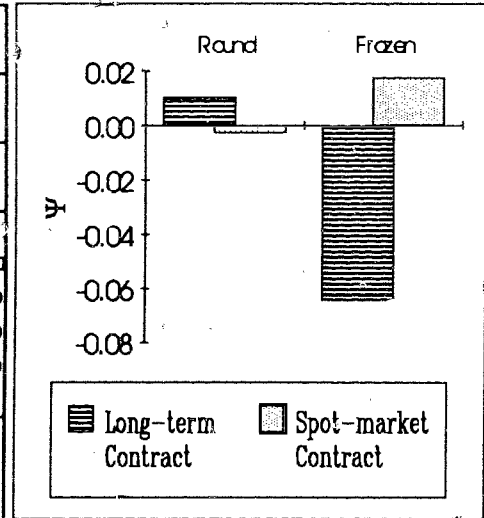
CONTINGENCY TABLE #2f

Salmon Gillnetters; 3 or More Licences

OBSERVED FREQUENCIES

	Round	Dressed	Total
Long-Term Contract	109	23	132
Spot Market Contract	443	119	562
Total	552	142	694

COMPUTED CHISQUARE	=	0.924	insignificant

CONTINGENCY TABLE #2g

Salmon Trollers; One Licence

OBSERVED FREQUENCIES

	Fresh	Frozen	Total
Long-Term Contract	249	20	269
Spot Market Contract	578	68	646
Total	827	88	915

COMPUTED CHISQUARE	=	2.09	$\alpha = .1$

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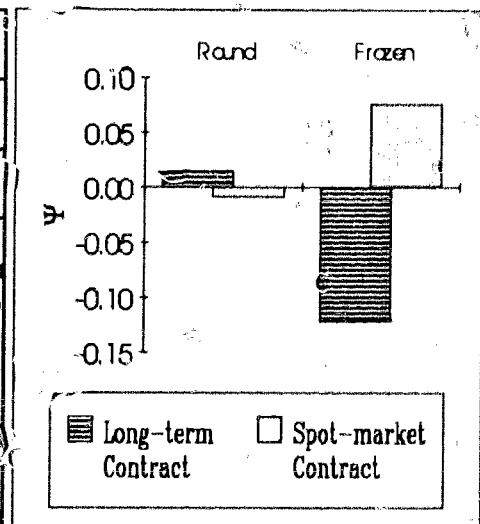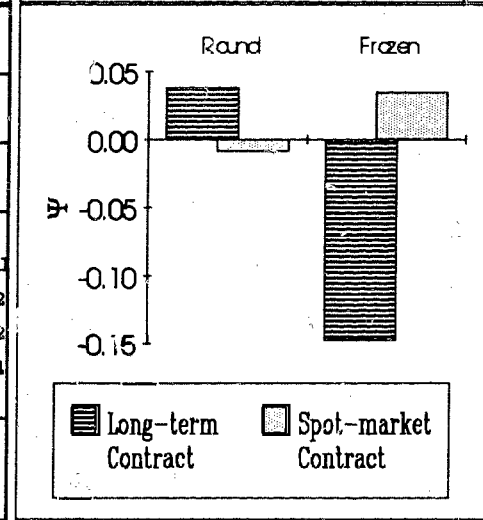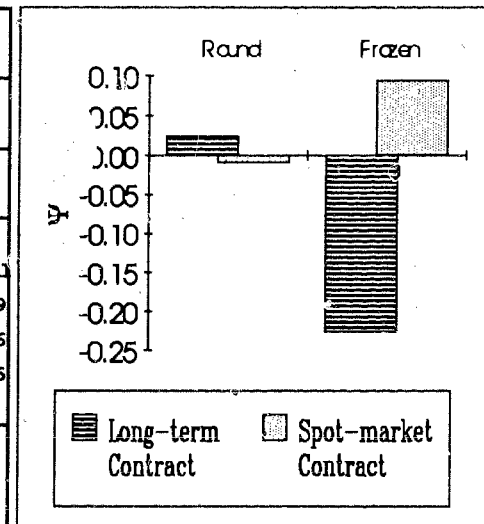<tr><td></td><td colspan="3">OBSERVED FREQUENCIES</td></tr>
<tr><td></td><td>Fresh</td><td>Frozen</td><td>Total</td></tr>
<tr><td>Long-Term Contract</td><td>216</td><td>27</td><td>243</td></tr>
<tr><td>SpotMarketContract</td><td>757</td><td>108</td><td>865</td></tr>
<tr><td>Total</td><td>973</td><td>135</td><td>1108</td></tr>
<tr><td>COMPUTED CHISQUARE</td><td>= 0.335</td><td colspan="2">insignificant</td></tr>
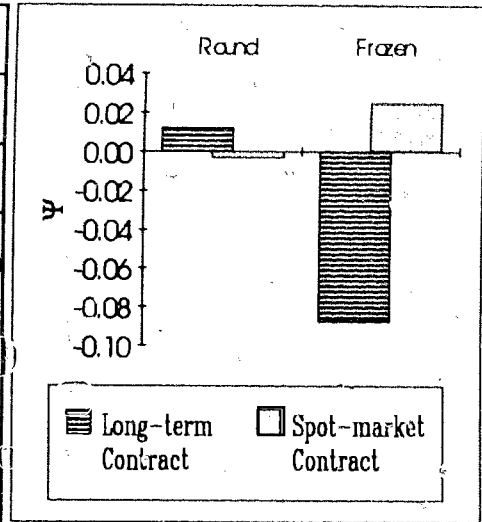</table>

<table>
<tr><td colspan="4">CONTINGENCY TABLE #2i</td></tr>
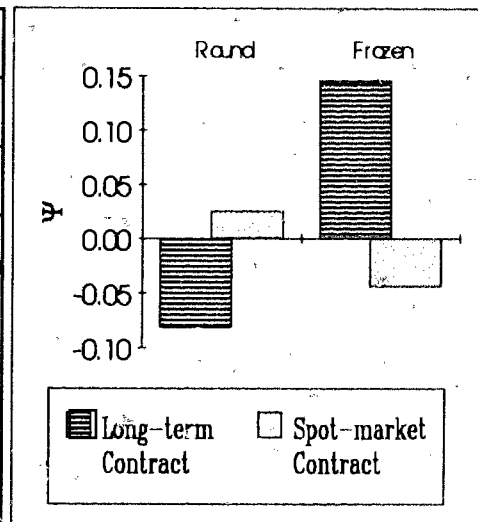<tr><td></td><td colspan="3">Salmon Trollers; 3 or More Licences</td></tr>
<tr><td></td><td colspan="3">OBSERVED FREQUENCIES</td></tr>
<tr><td></td><td>Fresh</td><td>Frozen</td><td>Total</td></tr>
<tr><td>Long-Term Contract</td><td>51</td><td>36</td><td>87</td></tr>
<tr><td>SpotMarketContract</td><td>186</td><td>98</td><td>284</td></tr>
<tr><td>Total</td><td>237</td><td>134</td><td>371</td></tr>
<tr><td>COMPUTED CHISQUARE</td><td>= 1.36</td><td colspan="2">insignificant</td></tr>
</table>

Contingency tables 2g to 2i refer to transactions involving salmon trollers. The sample consists of very few troller exchanges for which deliveries were in the round. Thus, these observations were categorized as fresh or frozen. Fresh deliveries include both the very few round deliveries as well as exchanges in which fish were dressed. As with the gillnet exchanges, delivered product-form is found to be insignificant in determining contractual choice for transactions in which vessels have two or more licences.

The above analysis indicates that the importance of perishability as a determinant of contractual choice decreases with the flexibility of the harvesting technology. In particular, perishability is an important determinant of contractual choice for transactions

The above analysis indicates that the importance of perishability as a determinant of contractual choice decreases with the flexibility of the harvesting technology. In particular, perishability is an important determinant of contractual choice for transactions involving seiners and for transactions in which the vessel is confined to operating in one fishery. This suggests that the flexibility of the harvesting technology across fisheries, and across intermediate and final product-forms, has a greater influence upon the choice of contractual arrangement than does perishability.

Specificity of the Harvesting Technology

Gear Type

In order to establish the importance of gear-type in the choice of contractual arrangement, a chi-square test is first conducted on the data of observed frequencies shown in contingency table #3. Of the 15,753 observations, 7,809 deliveries were from seiners, 4,940 from gillnetters, 257 from sablefish trap vessels, 352 from longliners, and 2,395 from trollers. The majority of seine and trap deliveries were exchanged under long-term contracts, while the majority of deliveries from the other gear-types were exchanged on the spot market. The highly significant computed chi-square statistic of 4,203.33 indicates that there is significant deviation of observed from expected frequencies across gear-types and contractual choice.

CONTINGENCY TABLE #3						
	OBSERVED FREQUENCIES					
	Seine	Gilnet	Trap	Longline	Troll	Total
Long-Term Contract	6286	1531	146	86	599	8648
Spot-Market Contract	1523	3409	111	266	1796	7105
Total	7809	4940	257	352	2395	15753
	EXPECTED FREQUENCIES					
	Seine	Gilnet	Trap	Longline	Troll	
Long-Term Contract	4286.94	2711.94	141.09	193.24	1314.79	
Spot-Market Contract	3522.06	2228.06	115.91	158.76	1080.21	

COMPUTED CHI-SQUARE $=$ 4203.33   CRITICAL CHI-SQUARE (4, .01) $=$ 13.29

The deviations of observed from expected frequencies, $\Psi_{r,c}$ are recorded below and illustrated in Figure 6-3. The deviation of observed frequency from that expected under the null hypothesis is positive for transactions involving fish delivered by seine and trap gear and negative for fish delivered by gillnetters, longliners and trollers. Given the previous specificity ranking across gear-types, the signs of Ψ for each category appear to be roughly consistent with the paper's hypothesis. That is salmon transactions in which the most specific gear-type, seine gear, is employed are conducted more frequently by long-term contract than expected under the null hypothesis. Similarly, transactions of sablefish trap landings are also conducted under long-term contract to a greater extent than catch harvested by the more flexible longline gear.

	(OBSERVED - EXPECTED)/EXPECTED				
	Seine	Gillnet	Trap	Longline	Troll
Long-Term Contract	0.47	-0.44	0.03	-0.55	-0.54
Spot-Market Contract	-0.57	0.53	-0.04	0.68	0.66

FIGURE 6-3

OBSERVED CONTRACTUAL CHOICE ACROSS GEAR-TYPE
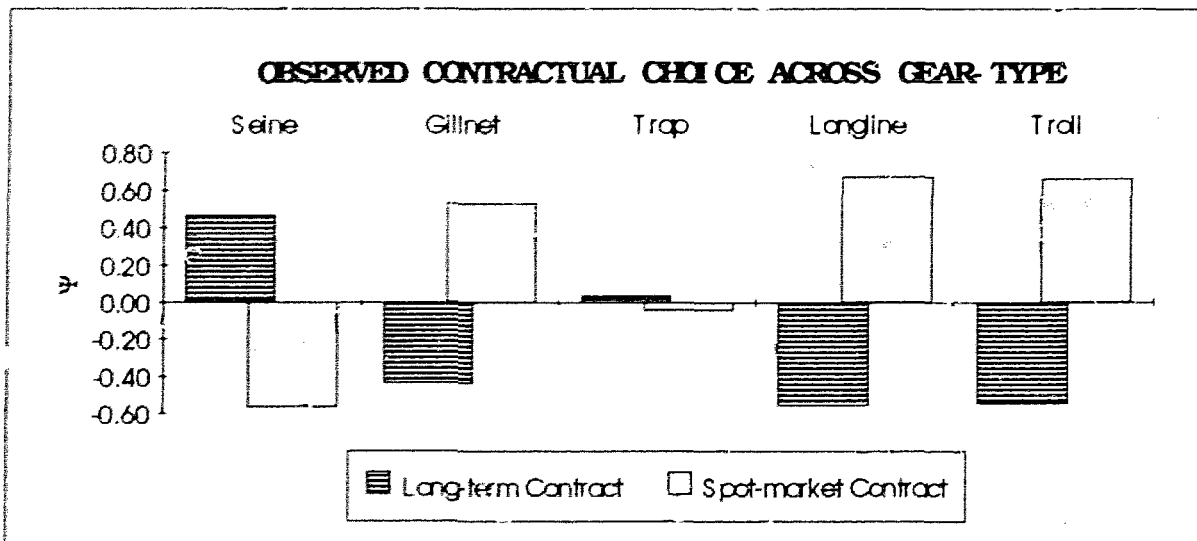
Note again, however that the above chi-square test does not allow us to definitively identify gear-type as an important determinant of contractual choice. This is because gear-type may be correlated with other variables that are proposed to contribute to contractual preference. Contingency tables 3a to 3h illustrate the observed frequencies of transactions across gear-type when all other variables that potentially affect contractual choice are held constant. In particular, for each of the chi-square tests, 3a to 3i, the following variables are held constant: species, delivered product-form, and number of licences attached to the vessel. The way in which contractual choice varies across gear-type is then analyzed.

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CONTINGENCY TABLE #3a			
Salmon, Round, One Licence			
OBSERVED FREQUENCIES			
	Seine	Gillnet	Total
Long-Term Contract	2804	1006	3810
Spot-Market Contract	703	1579	2282
Total	3507	2585	6092
COMPUTED CHISQUARE	= 1069.74		α = .001
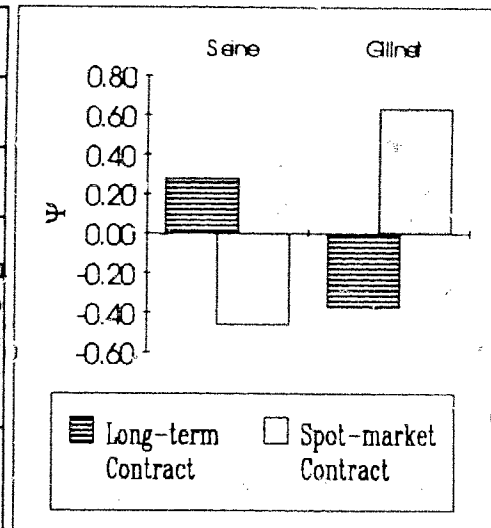
CONTINGENCY TABLE #3b			
Salmon, Round, Two Licences			
OBSERVED FREQUENCIES			
	Seine	Gillnet	Total
Long-Term Contract	2161	252	2413
Spot-Market Contract	193	930	1123
Total	2354	1182	3536
COMPUTED CHISQUARE	= 1803.63		α = .001
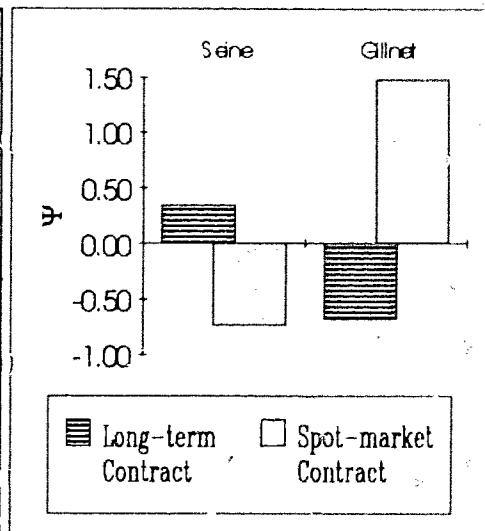
Contingency tables 3a to 3c illustrate the distribution of spot-market and long-term contract transactions across the seine and gillnet gear-types. All of these deliveries consisted of a round product-form. The deliveries referred to in Table 3a were all conducted by vessels with only one licence; those Table 3b by vessels with two licences, and those in Table 3c by vessels licenced to operate in three or more fisheries. The computed chi-square statistic is highly significant in each of these tests. Moreover, the deviation of observed from frequencies for each gear/contact classification is consistent

with the thesis' hypothesis. That is, transactions involving seine gear are overwhelmingly conducted via long-term contractual arrangements.

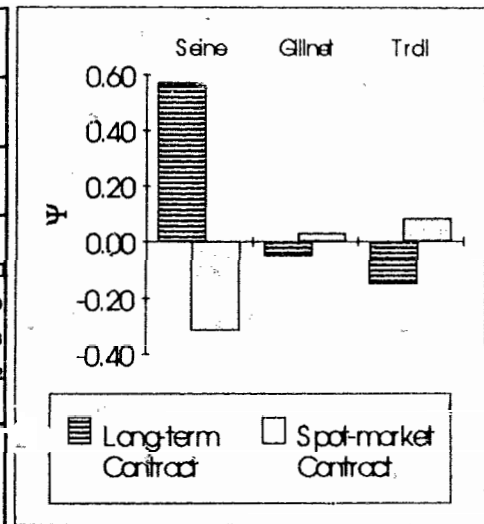| CONTINGENCY TABLE #3c			
	Salmon		
	Round; 3 or More Licences		
	OBSERVED FREQUENCIES		
	Seine	Gillnet	Total
Long-Term Contract	708	109	817
Spot Market Contract	276	445	721
Total	984	554	1538
COMPUTED CHISQUARE	= 388.97	α = .001	
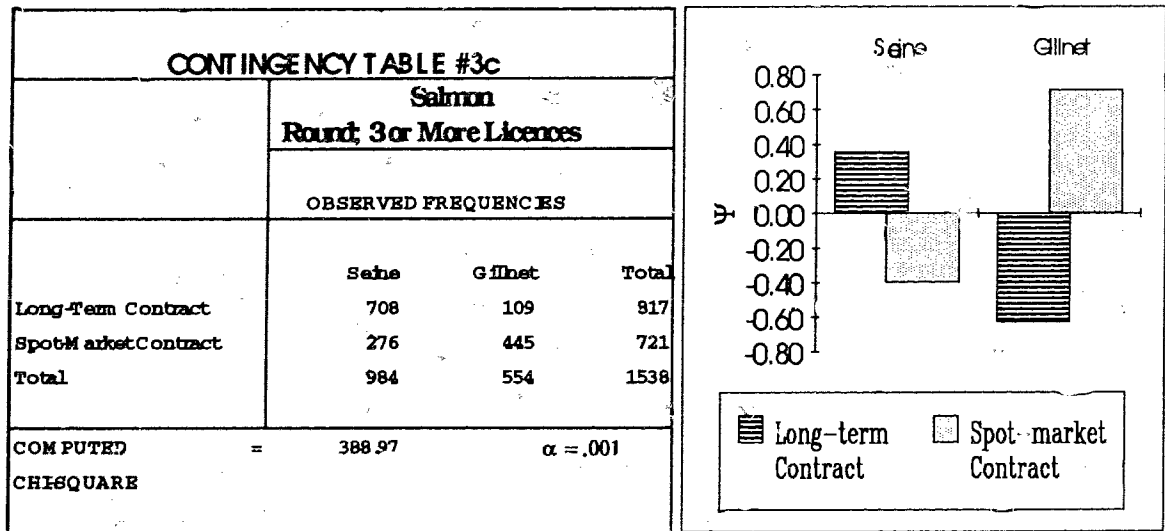
Contingency tables 3d to 3f illustrate the distribution of salmon transactions across the three gear-types employed in the salmon fishery. All of these deliveries consisted of a dressed intermediate product-form. The exchanges of fish summarized in Table 3d were all delivered by single-licensed vessels, and those in Tables 3e and 3f by multiple-licensed vessels. Again, the computed chi-square statistics are highly significant. The most transaction-specific gear-type, seine gear, was employed primarily in exchanges governed by long-term contract, while vessels equipped with the less specific gear-types, gillnetters and trollers, operated more heavily on the spot market.

Contingency tables 3g and 3h illustrate the distribution of sablefish deliveries, all of which were in a dressed product-form, across trap and long-line gear. The deliveries of sablefish referred to in Table 3g were conducted by vessels licenced to operate in fewer than three fisheries, while those referred to in Table 3h were conducted by vessels with three or more licences. The computed chi-square statistic is insignificant for contingency table 3g, but significant for contingency table 3h. The deviations of

observed from expected frequencies are positive for deliveries harvested by trap gear and negative for deliveries harvested by longline gear. This is consistent with the thesis' contention that the preference for long-term contracting is positively correlated with the presence of transaction-specific assets.

CONTINGENCY TABLE #3d				
Salmon; Dressed; One Licence				
OBSERVED FREQUENCIES				
	Seine	G.ffinet	Troll	Total
Long-Term Contract	136	105	248	489
Spot-Market Contract	107	206	570	883
Total	243	311	818	1372
COMPUTED CHISQUARE	=	54.35		$\alpha = .001$

CONTINGENCY TABLE #3e				
Salmon; Dressed; Two Licences				
OBSERVED FREQUENCIES				
	Seine	G.ffinet	Troll	Total
Long-Term Contract	172	37	216	425
Spot-Market Contract	55	149	748	952
Total	227	186	964	1377
COMPUTED CHISQUARE	=	257.34		$\alpha = .001$
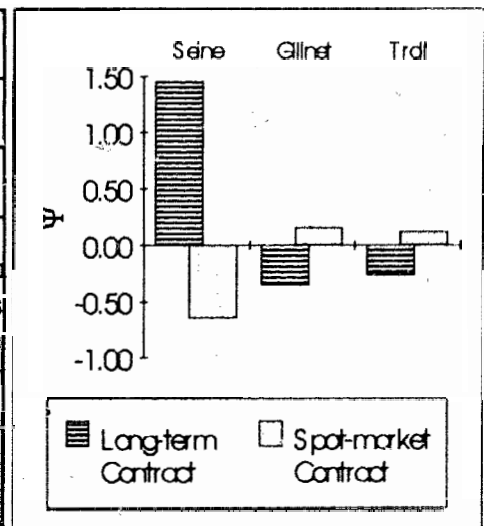
CONTINGENCY TABLE #3f

Salmon
Dressed; 3 or More Licences

OBSERVED FREQUENCIES

	Seine	Gillnet	Troll	Total
Long-Term Contract	131	23	51	205
Spot-Market Contract	79	119	184	382
Total	210	142	235	587

| COMPUTED CHISQUARE | = | 109.65 | | $\alpha = .001$ |

Seine   Gillnet   Trdl

Legend: Long-term Contract / Spot-market Contract
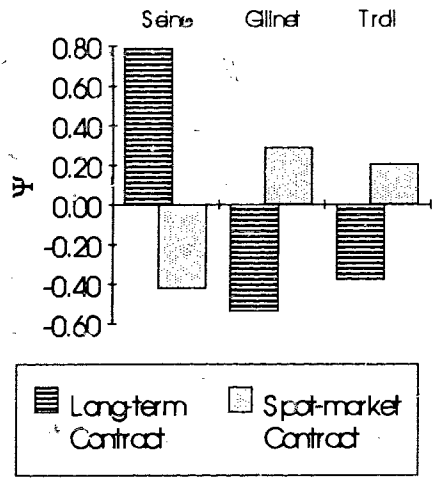
CONTINGENCY TABLE #3g

Sablefish
Dressed; Less than 3 Licences

OBSERVED FREQUENCIES

	Trap	Longline	Total
Long-Term Contract	47	4	51
Spot-Market Contract	28	6	34
Total	75	10	85

| COMPUTED CHISQUARE | = | 1.89 | insignificant |

Trap   Longline

Legend: Long-term Contract / Spot-market Contract
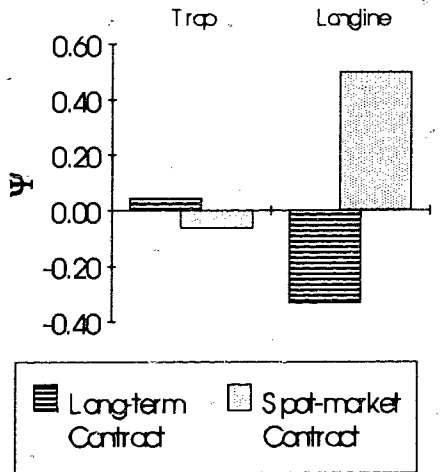
CONTINGENCY TABLE #3h

Sablefish
Dressed; 3 or More Licences

OBSERVED FREQUENCIES

	Trap	Longline	Total
Long-Term Contract	36	27	63
Spot-Market Contract	22	46	68
Total	58	73	131

| COMPUTED CHISQUARE | = | 8.15 | $\alpha = .005$ |

Trap   Longline

Legend: Long-term Contract / Spot-market Contract

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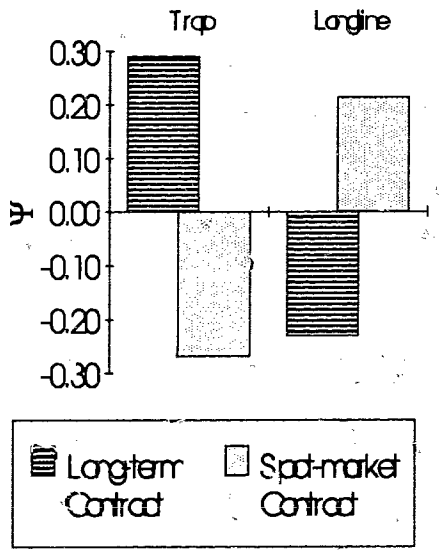
Vessel Flexibility

The flexibility of the vessel across fisheries and intermediate product is captured by observing differences in contracting behaviour between single-licensed and multiple-licensed vessels. Contingency table #4 illustrates the distribution of spot-market and long-term transactions across categories denoting the number of licences attached to the vessel. Of the 15,753 transactions, 7,605 were conducted by vessels with only one licence (or tab), 5,454 by vessels with two licences, 2,250 by vessels with 3 licences, and 494 by vessels with 4 or more licences. The majority of transactions in which vessels had two or fewer licences were governed by long-term contracts. Conversely, vessels with multiple licences operated primarily on the spot market.

CONTINGENCY TABLE #4					
	OBSERVED FREQUENCIES				
	1 T ab	2 T abs	3 T abs	>3 T abs	Total
Long-Term Contract	4385	3117	995	201	8648
Spot-Market Contract	3270	2337	1255	243	7105
Total	7605	5454	2250	444	15753
	EXPECTED FREQUENCIES				
	1 T ab	2 T abs	3 T abs	>3 T abs	
Long-Term Contract	4174.95	2994.11	1235.19	243.74	
Spot-Market Contract	3430.05	2459.89	1014.81	200.26	

COMPUTED CHI-SQUARE = 132.78   CRITICAL CHI-SQUARE (3, .01) = 11.35

The computed chi-square statistic is significant, implying that the vessel's flexibility across fisheries is an important determinant of contractual choice. The

deviations of observed from expected frequencies, $\Psi_{r,c}$, are shown in the following table, and graphically depicted in Figure 6-4.

	(OBSERVED - EXPECTED)/EXPECTED			
	1 T ob	2 T obs	3 T obs	>3 T obs
Long-Term Contract	0.05	0.04	-0.19	-0.18
Spot-Market Contract	-0.05	-0.05	0.24	0.21

Transactions governed by spot-market contracts are observed to increase with vessel flexibility. That is, multiple-licensed vessels are less specific to the the production of a particular intermediate product, and, therefore, less specific to a particular transaction. The thesis' hypothesis implies that as assets become less transaction-specific, there is a decreased probability of exchanging under a long-term contract.

FIGURE 6-4

OBSERVED CONTRACTUAL CHOICE ACROSS NUMBER OF VESSEL LICENCES
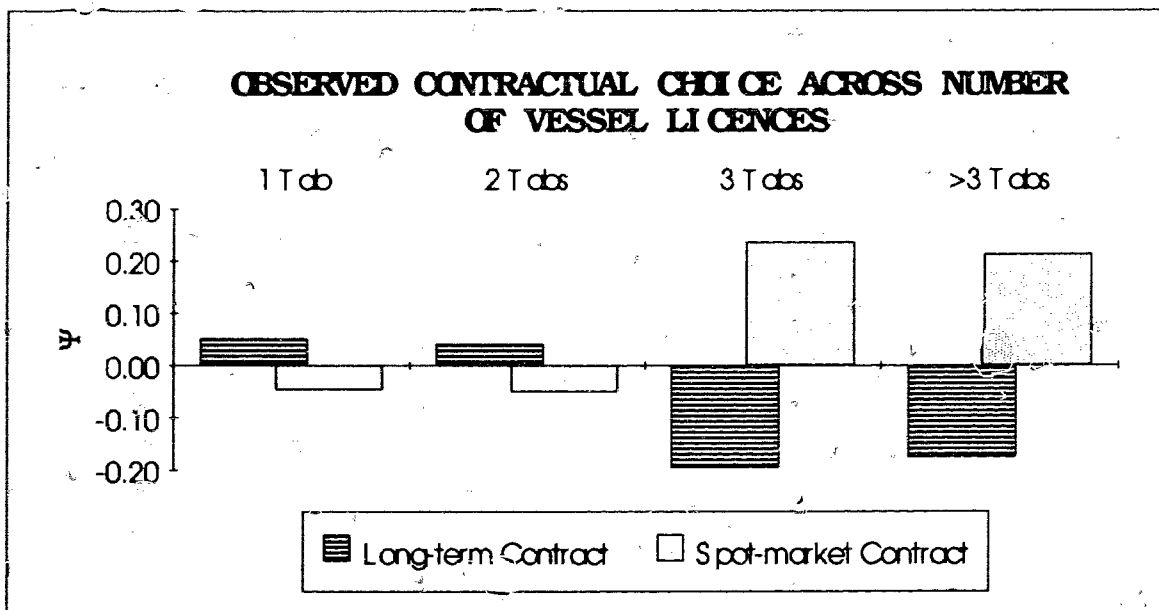
In order to ensure that it is indeed vessel flexibility that is guiding contractual preference, an additional series of tests are conducted which hold constant other variables that potentially contribute to contractual choice. Contingency tables 4a to 4j report the distributions of spot-market and long-term transactions across numbers of vessel licences while holding constant species, gear-type and delivered product-form.

For salmon transactions, illustrated in tables 4a to 4f, the chi-square statistic is significant for each of the tests. The deviations of observed from expected frequencies, Ψ, in each classification are, in general, as predicted by the thesis' hypothesis. That is, transactions in which the vessel has few licences tend to be dominated by strong vertical ties between fisher and processor.

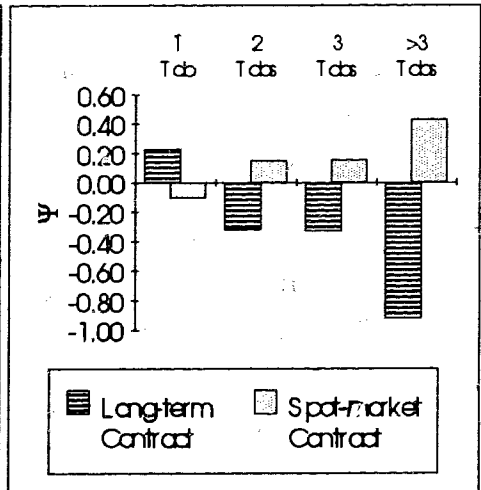| CONTINGENCY TABLE #4a					
Salmon; Seine Gear; Round					
OBSERVED FREQUENCIES					
	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	2804	2161	586	122	5673
Spot-Market Contract	703	193	238	38	1172
Total	3507	2354	824	160	6845
COMPUTED CHISQUARE	=	238.49			$\alpha = .001$

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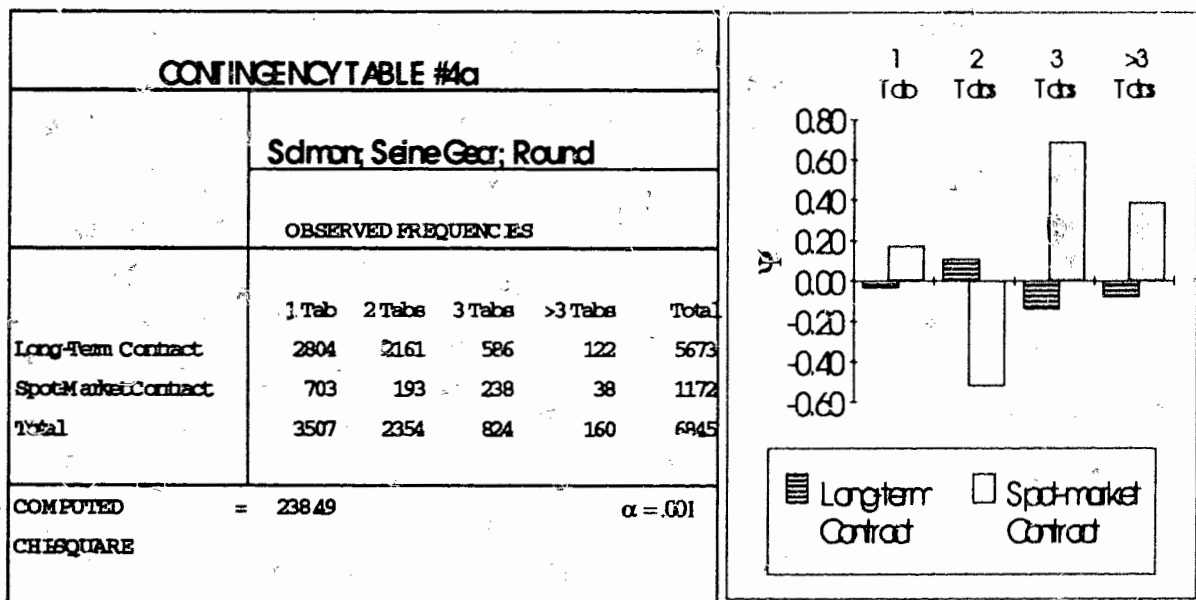
[7]Note that in tests 4a and 4b there are fewer than expected (under the null) exchanges governed by long-term contracts for vessels with only one licence. This result is not consistent with the thesis' hypothesis.
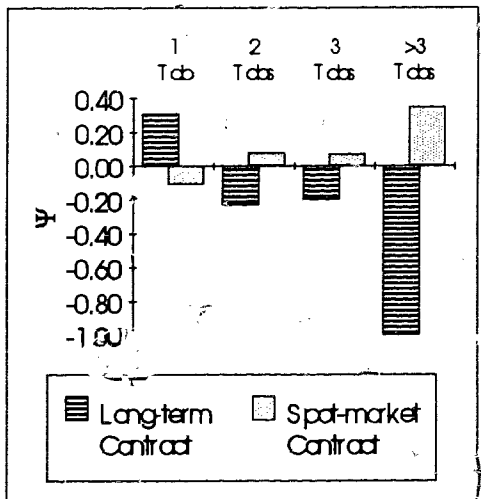
CONTINGENCY TABLE #4b

Salmon; Seine Gear; Dressed

OBSERVED FREQUENCIES

	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	136	172	128	3	439
Spot Market Contract	107	55	76	3	241
Total	243	227	204	6	680

COMPUTED CHISQUARE	=	21.16		$\alpha = .001$
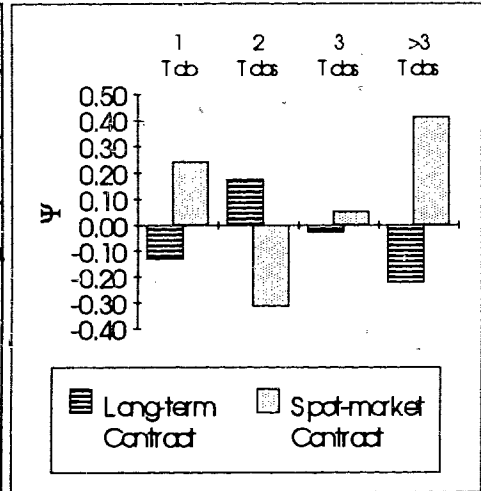
CONTINGENCY TABLE #4c

Salmon; Gillnet Gear; Round

OBSERVED FREQUENCIES

	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	1005	252	108	1	1366
Spot Market Contract	1571	921	402	41	2935
Total	2576	1173	510	42	4301

COMPUTED CHISQUARE	=	162.79		$\alpha = .001$

CONTINGENCY TABLE #4d

Salmon; Gillnet Gear; Dressed

OBSERVED FREQUENCIES

	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	105	37	23	0	165
Spot Market Contract	206	149	88	31	474
Total	311	186	111	31	639

COMPUTED CHISQUARE	=	25.95		$\alpha = .001$

CONTINGENCY TABLE #4e

Salmon; Troll Gear; Fresh Dressed

OBSERVED FREQUENCIES

	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	249	216	43	8	516
SpotMarketContract	578	757	159	27	1521
Total	827	973	202	35	2037

COMPUTED CHISQUARE	=	16.89		$\alpha = .001$
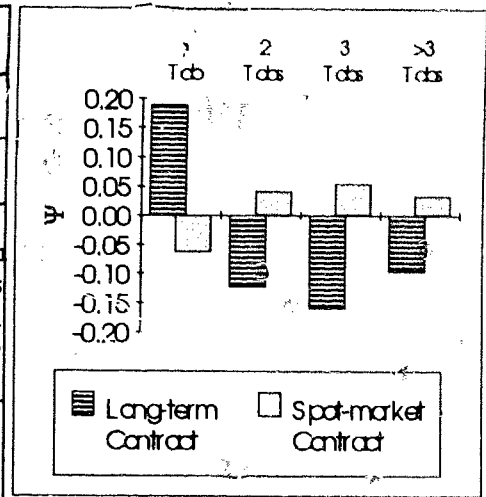
CONTINGENCY TABLE #4f

Salmon; Troll Gear; Frozen

OBSERVED FREQUENCIES

	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	20	27	17	19	83
SpotMarketContract	68	108	69	29	274
Total	88	135	86	48	357

COMPUTED CHISQUARE	=	8.57		$\alpha = .05$
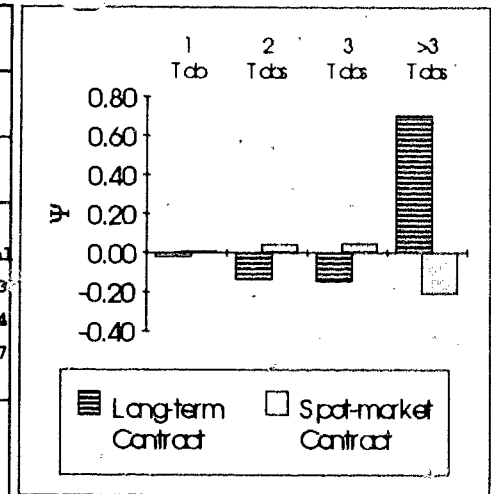
CONTINGENCY TABLE #4g

Longline Gear; Fresh Dressed

OBSERVED FREQUENCIES

	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	7	5	42	27	81
SpotMarketContract	4	45	150	58	257
Total	11	50	192	85	338

COMPUTED CHISQUARE	=	18.15		$\alpha = .001$
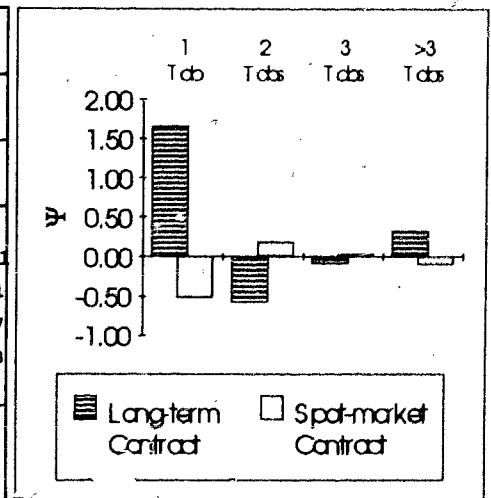
CONTINGENCY TABLE #4h					
	Herring; Seine Gear; Round				
	OBSERVED FREQUENCIES				
	1 Tab	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	7	147	17	3	174
SpotMarketContract	6	73	27	4	110
Total	13	220	44	7	284
COMPUTED CHISQUARE = 13.65				$\alpha = .01$	
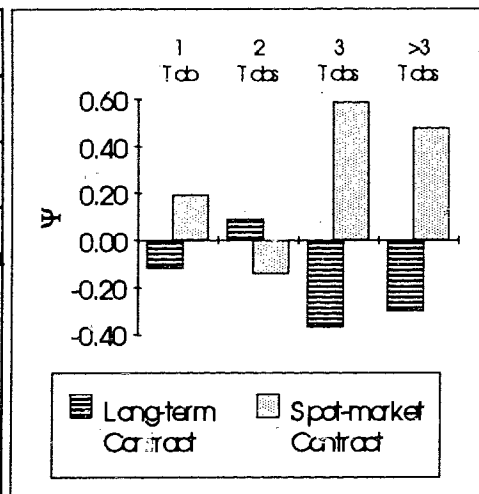
Contingency table 4g illustrates the distribution of both sablefish and halibut longline deliveries across contractual arrangement.[8] The chi-square statistic is significant and the deviations of observed from expected frequencies, Ψ, as predicted by the thesis' hypothesis.

Contingency table 4h refers to observations of herring seine deliveries, all of which were in the round. The computed chi-square statistic is significant at $\alpha = .01$. The deviations of observed from expected frequencies are consistent with the thesis' hypothesis with the exception of the single-licence classification. Here, more transactions than expected under the null hypothesis were conducted on the spot-market. The thesis' hypothesis predicts that fewer than expected under the null hypothesis would be conducted on the spot market.

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[8]Sablefish and halibut deliveries have been combined for this test because there are an insufficient number of fresh-dressed sablefish deliveries by longliners to allow a separate test.

CONTINGENCY TABLE #4i

Sablefish; Trap Gear; Round

OBSERVED FREQUENCIES

	2 Tabs	3 Tabs	>3 Tabs	Total
Long-Term Contract	52	5	6	63
SpotMarketContract	18	1	8	27
Total	70	6	14	90

COMPUTED CHISQUARE	=	6.03	$\alpha = .05$
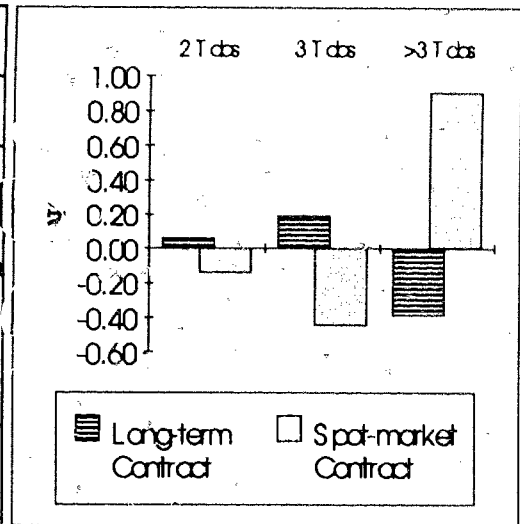
CONTINGENCY TABLE #4j

Sablefish; Trap Gear; Dressed

OBSERVED FREQUENCIES

	< 3 Tabs	>2 Tabs	Total
Long-Term Contract	47	36	83
SpotMarketContract	28	22	50
Total	75	58	133

COMPUTED CHISQUARE	=	0.004	insignificant
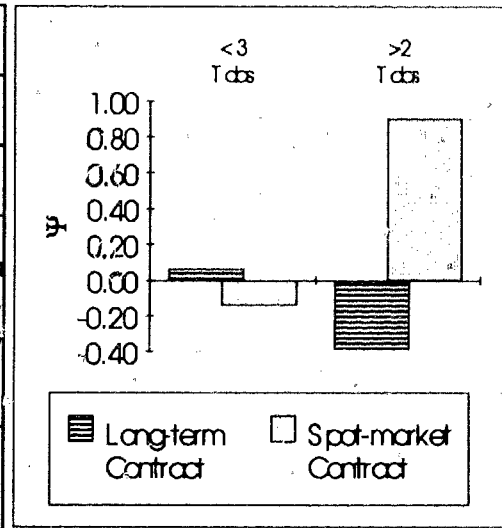
Contingency tables 4i and 4j refer to transactions of sablefish. The effect of vessel flexibility across fisheries on contractual choice is found to be significant for vessels using trap gear and delivering a round product form, but insignificant for vessels delivering a fresh dressed intermediate product. The deviations of observed from expected frequencies are consistent with the predictions of the thesis' hypothesis.

The above chi-square tests indicate that the specificity of the vessel to a particular fishery is directly related to the incidence of transactions governed by long-term contracts.


Flexibility of the Processing Technology

In order to account for the effect of investment specificity in processing upon contractual choice, each exchange is characterized as either between a fisher and a processor with canning facilities, or between a fisher and a processor without canning facilities. Recall that investments in canning equipment are highly specific to the production of canned salmon. Other investments in processing (eg., freezing capacity) are more flexible across intermediate and final products.

CONTINGENCY TABLE #5			
OBSERVED FREQUENCIES			
	Canning Facilities	No Canning Facilities	Total
Long-Term Contract	7319	923	8242
Spot-Market Contract	3658	2963	6621
Total	10977	3886	14863
EXPECTED FREQUENCIES			
	Canning Facilities	No Canning Facilities	
Long-Term Contract	6087.09	2154.91	
Spot-Market Contract	4889.91	1731.09	
COMPUTED CHI-SQUARE = 2140.59		CRITICAL CHI-SQUARE (1, .01)	6.64

Contingency table #5 summarizes the distribution of salmon deliveries across processors that have canning facilities and those that do not. Of the 14,863 observations of salmon deliveries, 10,977 were made to companies that have canning facilities and 3,886 to companies without canning facilities. The vast majority of exchanges between fishers and canners were governed by long-term contracts, while the majority of deliveries to non-canners were conducted on the spot market. The chi-square statistic is highly significant, implying that specificity in processing is a primary determinant of contractual choice. The direction of deviations from observed and expected frequencies, illustrated in Figure 6-5, are consistent with the thesis' hypothesis.

FIGURE 6-5
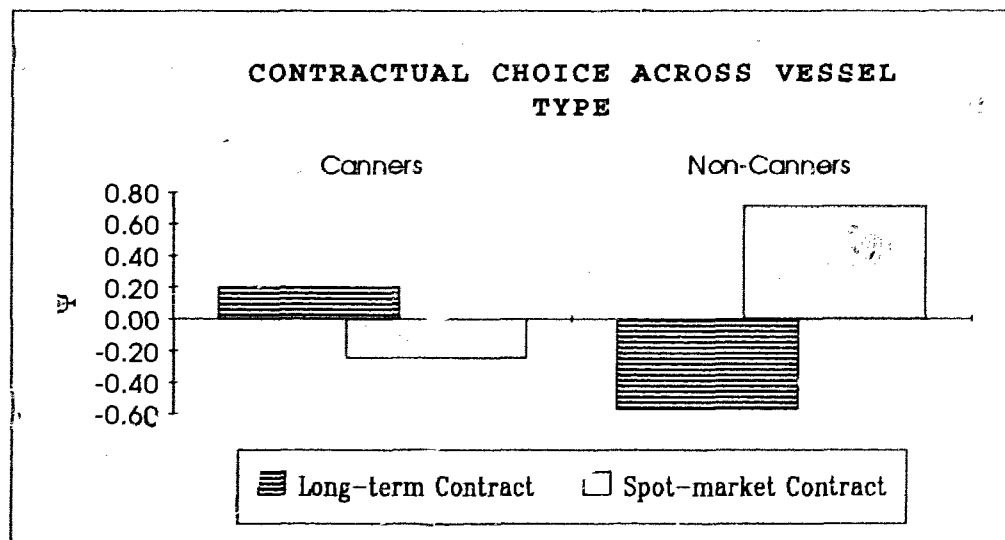
In order to more definitively establish support for the contention that specificity in processing contributes to contractual preference, an additional series of tests are conducted which hold constant other variables that potentially contribute to contractual choice. Contingency tables 5a to 5f illustrate the distribution of spot-market and long-

term transactions across canners and non-canners while holding constant the following variables: delivered product-form, gear-type, and number of vessel licences. Only transactions involving a round product-form are considered, since no other product-form (i.e., dressed or frozen) is directed toward the canned market. Each of the corresponding chi-square tests is significant with the exception of that for contingency table #5c. Moreover the deviations of observed from expected (under the null) frequencies are positive for long-term transactions between fishers and canners, and negative for long-term transactions between fishers and non-canners. This indicates a positive correlation between the incidence of vertical ties and asset-specificity in the processing technology.

CONTINGENCY TABLE #5a			
	Salmon Seiners Round; One Licence		
	OBSERVED FREQUENCIES		
	Canner	Non-Canner	Total
Long-Term Contract	2658	146	2804
Spot-Market Contract	553	150	703
Total	3211	296	3750
COMPUTED CHISQUARE	=	218.1	$\alpha = .001$
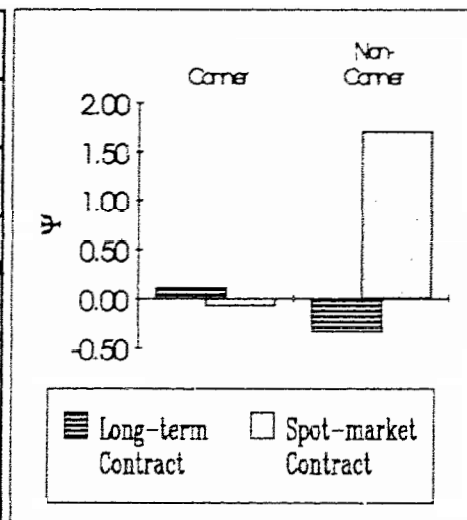
CONTINGENCY TABLE #5b			
	Salmon Seiners Round; Two Licences		
	OBSERVED FREQUENCIES		
	Canner	Non-Canner	Total
Long-Term Contract	2006	155	2804
Spot-Market Contract	92	101	703
Total	2098	256	3750
COMPUTED CHISQUARE	=	418.18	$\alpha = .001$

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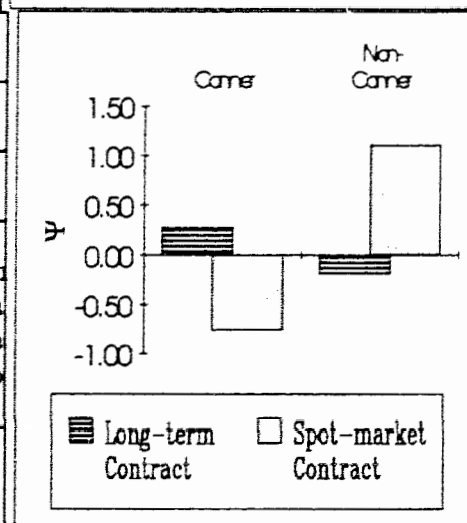
CONTINGENCY TABLE #5c			
	Salmon Seiners		
	Round 3 or More Licences		
	OBSERVED FREQUENCIES		
	Canner	Non-Canner	Total
Long-Term Contract	590	118	708
Spot-Market Contract	219	57	276
Total	809	175	984
COMPUTED CHISQUARE =	2.16		insignificant
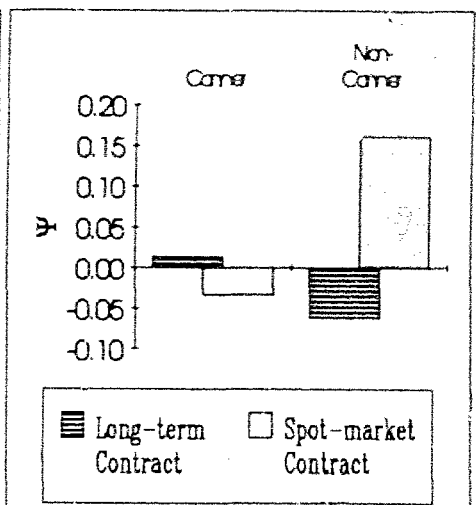
CONTINGENCY TABLE #5d			
	Salmon Gillnetters		
	Round 1 Licence		
	OBSERVED FREQUENCIES		
	Canner	Non-Canner	Total
Long-Term Contract	897	151	1048
Spot-Market Contract	844	693	1537
Total	1741	844	2585
COMPUTED CHISQUARE =	266.72		$\alpha = .001$
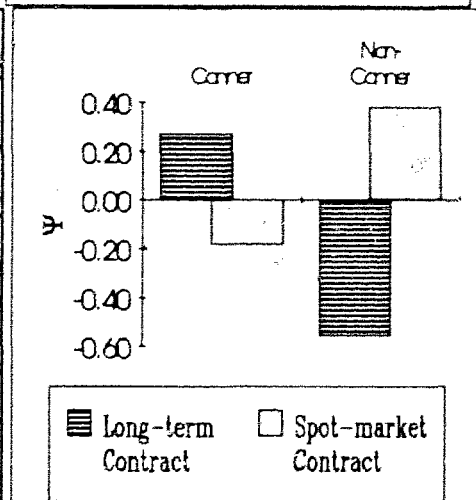
CONTINGENCY TABLE #5e			
	Salmon Gillnetters		
	Round 2 Licences		
	OBSERVED FREQUENCIES		
	Canner	Non-Canner	Total
Long-Term Contract	219	33	252
Spot-Market Contract	582	348	930
Total	801	381	1182
COMPUTED CHISQUARE =	53.71		$\alpha = .001$
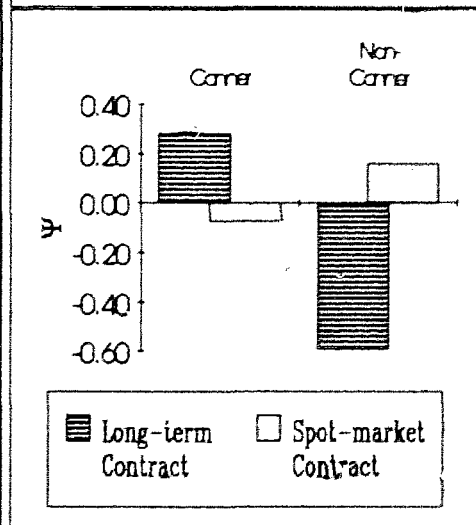
CONTINGENCY TABLE #5f			
	Salmon Gillnetters Round 3 or More Licences		
	OBSERVED FREQUENCES		
	Canner	Non-Canner	Total
Long-Term Contract	109	0	109
Spot-Market Contract	253	192	445
Total	362	192	554
COMPUTED CHISQUARE	71.97	α = .001	

Long-term Contract   Spot-market Contract
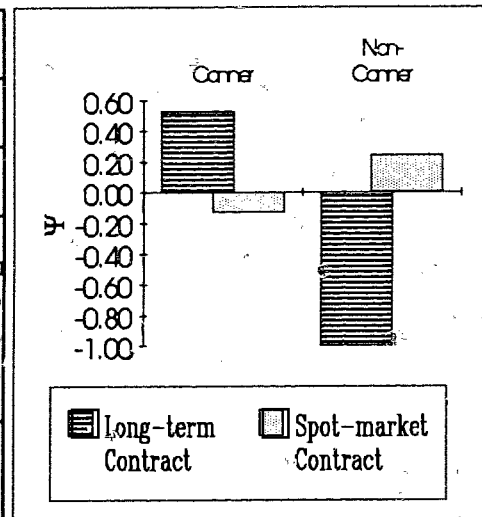
The foregoing non-parametric empirical analysis offers strong support for the thesis' contention that contractual choice in the intermediate market for raw fish is determined by the presence of transaction-specific assets in both harvesting and processing. The results of the empirical analysis can be summarized as follows:

- The following variables have been identified as important determinants of contractual choice: perishability of the intermediate product-form, flexibility of the gear across intermediate product-forms, and flexibility of the fishing vessel across fisheries.

- There exists a positive correlation between the degree of asset-specificity and the incidence of transactions conducted via incomplete long-term contracts

- The higher is the degree of asset-specificity, the stronger is the vertical tie existing between fisher and processor.

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The Probit Model

The probit model belongs to the general class of qualitative choice models. All qualitative choice models calculate the probability that a decision-maker will choose a particular alternative from a set of alternatives, given categorical data, Y^k ($k = 1, \ldots, K$) observed by the researcher. The models differ in the functional form that relates the observed data to the probability (Train, 1986: 7).

The probit probability model is associated with the cumulative normal probability function. Assume that there exists a theoretical index Z which is determined by a vector of explanatory variables X. The index Z is assumed to be a continuous variable which is random and normally distributed.

$$Z_i = \alpha + \beta X_i$$

It is assumed that observations on Z are not available; instead, the data distinguishes only whether individual observations are in one category (i.e., one range of the index Z_i) or a second category (another range of Z_i). Probit analysis obtains estimates for the parameters α and β and the relationship between Z and the observed categorical variable, Y^k (Pindyck and Rubinfeld, 1981: 281).

How can the probit model be applied to contractual choice in the intermediate market for raw fish? The variable Z can be interpreted as the propensity of the exchange to *ex post* hold-up. In this particular application, then, Z is a theoretical construct based on the model presented in Chapter 3. Although Z is unobservable, the available data (information on vessel ownership and financing, and bonus payments) indicates whether, based on the thesis' hypothesis, Z takes on high values (i.e., there is a high propensity to hold-up) or whether Z takes on low values (i.e., there is a low propensity to hold-up). According to the thesis' hypothesis, high values of Z increase the probability that the

transaction is conducted under an incomplete, long-term contract. Assume that the propensity of an exchange to hold-up is a linear function of the vector of explanatory variables **X**. Then the probit model provides a suitable means of estimating the slope and intercept parameters of the relationship between the propensity to hold-up and the proposed explanatory variables.

The Binary Probit Model

It is useful to first model a binary choice problem. How does the underlying index Z relate to the actual contractual information available? Let Y represent a dummy variable which equals 1 when the vessel is owned or financed by the processor, or when the processor compensated the fisher with a season-end bonus, and 0 otherwise. Then assume that, for each individual transaction, Z_i^* represents the critical cutoff value which translates the underlying index into a contractual choice. Specifically.

$$Y_i = 1 \quad \text{if } Z_i > Z_i^*,$$
$$= 0 \quad \text{if } Z_i \leq Z_i^*$$

The probit model assumes that Z_i^* is a normally distributed random variable. The probability that Z_i^* is less than or equal to Z_i can be computed from the cumulative normal probability function. The standardized normal distribution function is written

$$P_i = F(Z_i) = \frac{1}{\sqrt{2\Pi}} \int_{-\infty}^{Z_i} e^{-s^2/2} ds$$

where s is a random variable which is normally distributed with mean zero and unit variance. To obtain an estimate of the index Z_i we apply the inverse of the cumulative normal function (Pindyck and Rubinfeld, 1981: 281-282):

$$Z_i = F^{-1}(P_i) - \alpha + \beta X_i$$

The estimated coefficients, β, reflect the effect of a change in an independent variable upon Z_i. The magnitude of the increase in probability depends upon the original probability and thus upon the initial values of all the independent variables and their coefficients. Thus, while the sign of the estimated coefficient indicates the *direction* of change, the magnitude depends upon the probability density function, or the steepness of the cumulative density function (Judge et. al., 1981: 767).

The probability that transaction i is governed by a long-term contract, Y_i, depends upon the propensity of transaction i to *ex post* hold-up, Z_i, which is in turn dependent upon the degree of asset specificity in transaction i. Asset-specificity in transactions is accounted for by the following vector of explanatory variables, X_i:

$X_i = [CAN?_i, \%DELIV_i, TRAP?_i, GILLNET?_I, SEINE?_I, ROUND?_i, WEIGHT_i, TABS_i]$

and:

CAN?$_i$ = 1   if the ith transaction involved a processor that had invested in canning facilities

     = 0   otherwise

$\%DELIV_i$ = percentage of 1988 industry catch delivered to the buyer

TRAP?$_i$ = 1   if transaction i involved the employment of trap gear

     = 0   otherwise

$GILLNET?_i = 1$ if transaction i involved the employment of gillnet gear

           $= 0$ otherwise

$SEINE?_i = 1$ if transaction i involved the employment of seine gear

           $= 0$ otherwise

$ROUND?_i = 1$ if transaction i consisted of fish delivered in the round

           $= 0$ otherwise

$WEIGHT_i = $ volume of catch delivered

$TABS_i = $ number of additional fishery-specific licences attached to the vessel involved in transaction i

The variable $CAN?_i$ is intended to account for the existence of asset-specificity in the processing technology. As $CAN?_i$ increases from 0 to 1, the processor's investment becomes more specific to the transaction. The variable $\%DELIV_i$ denotes the concentration of deliveries to the individual processor; the purpose of including this variable is to explore the Schwindt-Schaffer-Pinkerton hypothesis that industry concentration is the most important determinant of non-price competition. Increases in industry concentration are hypothesized to lead to a higher incidence of vertical ties. The remaining variables ($TRAP?_i$, ... $TABS_i$) serve as proxies for capturing the degree of asset-specificity embodied in the harvesting technology. With the exception of $TABS_i$, observations on these variables are each entered so that they positively correspond to higher levels of asset-specifity. An increase in the variable $TABS_i$ indicates an increase in the number of fishery-specific licences attached to the vessel; thus, higher values for $TABS_i$ corresponds to a lower degree of asset specificity.

A test of the hypothesis $H_0 : \beta_1 = \beta_2 = \ldots = \beta_8 = 0$ is conducted using the likelihood ratio procedure. If n is the number of successes ($Y_i = 1$) observed in the T observations, then the maximum value of the log-likelihood function under the null hypothesis is:

$$\ln L(\hat{\omega}) = n \ln \left(n/T \right) + (T - n) \ln \left(T - n/T \right) \tag{6-1}$$

Consequently, if the hypothesis is true, then asymptotically

$$-2[\ln L(\hat{\omega}) - \ln L(\hat{\Omega})] \tag{6-2}$$

has a $\chi^2_{(K-1)}$ distribution, where $\ln L(\hat{\Omega})$ is the value of the log-likelihood function evaluated at β', the maximum likelihood estimators[9] (Judge, et.al., 1985: 767). Acceptance of the null hypothesis implies that none of the explanatory variables has any effect on the propensity of the transaction to *ex post* hold-up.

Table 6-1 summarizes the results of the binary probit analysis. The computed χ^2 statistic is easily accepted at a very high level of confidence. Of particular interest are the signs of the estimated coefficients and their associated t-ratios[10].

The t-statistics indicate that each variable is highly significant at greater than the 99% level. Moreover, the signs of the estimated coefficients are largely consistent with the thesis' hypothesis. Note that, with the exception of TABS, an increase in each of the independent variables causes an increase in the degree of specificity in the transaction. Thus, the thesis' hypothesis implies that the estimated coefficients on these variables should be positive (i.e., an increase in asset specificity leads to an increased The only variable for which this is not true is the variable GILLNET?. Note that there are three

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[9] The maximum likelihood estimators are those values of β that maximizes the likelihood function, i.e., the values of β that gives the highest probability that the sampled decisionmakers would choose the alternatives that they actually did choose (Train, 1986: 45).

[10] The t-ratio for each of the variables is computed as follows: $t_{N-2} = (\beta' - \beta_0) / s_{\beta'}$, where β' is the estimated coefficient, and $s_{\beta'}$ is the estimate of its standard error.

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Table 6-1: Binary Probit Regression

Log-Likelihood	-8007.3
Restricted Log-Likelihood	-10843
Chi-Square (8)	5672.2
Level of Significance	3.20E-14

Variable	Coefficient	Std. Error	T-Ratio
ONE	-1.039	0.034	-30.61
CAN?	0.728	0.033	22.06
%DELIV	0.008	0.001	6.00
TRAP?	1.22	0.091	13.41
GILLNET?	-0.177	0.047	-3.74
SEINE?	1.1	0.046	23.78
ROUND?	0.156	0.039	4.00
WEIGHT	2.00E-07	6.00E-08	2.79
TABS	-0.091	0.014	-6.40

dummy variables denoting gear-type. The fourth implicit dummy variable represents two gear-types, longline and troll gear. A negative coefficient on GILLNET? is therefore interpreted as follows: a change in gear-type from troll or longline gear to gillnet gear, reduces the probability that the transaction is governed by an incomplete, long-term contract. If gillnet gear is indeed more specific to a particular transaction than is longline or troll gear, a negative coefficient on GILLNET? is inconsistent with the thesis' hypothesis.

Note that the industry concentration variable, %DELIV, is (significantly) positively correlated with contractual choice. Both the strategic collusion rationale for non-price competition, and the rationale proposed by this thesis are consistent with this outcome. Recall that the strategic collusion hypothesis, proposed by Shaffer (1979), Schwindt (1982) and Pinkerton (1987), states that non-price competition is used by oligoposinistic processors to avoid the erosion of profits that would result from price

competition. This hypothesis implies that processors with a larger share of the raw salmon market are more likely to form vertical ties (i.e., long-term contracts) with fishers than are buyers with an insignificant market share. Conversely, the hypothesis posed by this thesis suggests that the probability of a long-term contract increases with the propensity of the exchange to *ex post* hold-up. The propensity to hold-up is greater the fewer are the number of potential alternative exchanges. The larger is the share of fish landings purchased by the buying party in the transaction, the fewer are the alternative exchanges available to the seller.

Direct comparisons between the estimated coefficients shown in Table 6-1 must be undertaken with caution. The normalization made in conducting the probit estimation generally leads to coefficients of an arbitrary scale. It is the relative magnitudes of coefficients that is important rather than their absolute sizes (Pindyck and Rubinfeld, 1985: 284-285). Moreover, interpretation of the estimated coefficients must recognize differences in the scale of measurement used for each of the explanatory variables[11].

Recall that the above model estimates the relationship between the explanatory variables and Zi, the probability that the transaction would involve *ex post* hold-up. For example, the estimated coefficient for SEINE? may be interpreted as follows: in moving from troll or longline gear to seine gear, where the latter is more specific to the transaction, the propensity of the transaction to *ex post* hold-up (Zi) increases by 1.1. This increased propensity to hold-up increases the probability that the parties to the transaction will engage in long-term contracting (Y_i). The estimated coefficient for WEIGHT is interpreted as follows: a 1 pound increase in the volume of deliveries to the

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[11]The estimated coefficients on %DELIV and WEIGHT are deceptively small relative to the other coefficients. A unit change in %DELIV is a percentage point, while a unit change in WEIGHT is one pound of catch. Both are continuous scales of measurement. Since the other regressors are dummy variables the scales of measurement are discrete. Thus, a unit change in a discrete regressor is likely to have a much greater impact than a unit change in a continous regressor.

processor increases the propensity of the exchange to hold-up by $2E^{-7}$; this in turn leads to increased probability of a long-term contract.

The Multinomial Ordered Probit Model

The above analysis models the contractual choice problem as having only two possible alternatives so that the dependent variable is dichotomous. That is, decision-makers elect to exchange the intermediate product on the spot market or under an incomplete, long-term contract. It is useful to model contractual choice so as to allow for more than two possible outcomes. In particular, the *multinomial ordered probit* can be applied in the following way[12]:

$$Y_i = \begin{cases} 4 & \text{if } Z_i > \mu_3 \\ 3 & \text{if } \mu_2 < Z_i \le \mu_3 \\ 2 & \text{if } \mu_1 < Z_i \le \mu_2 \\ 1 & \text{if } \mu_0 < Z_i \le \mu_1 \\ 0 & \text{if } Z_i \le \mu_0 \end{cases}$$

Thus, the ordered probit model assumes there are cutoff points, μ_0, μ_1, μ_2, and μ_3 which define the relationship between the observed and unobserved dependent variables. As in the binary probit model, the parameters are estimated using a maximum-likelihood nonlinear estimation routine (Pindyck and Rubinfeld, 1981: 308). Let $Y_i = 4$ if the processor had majority ownership in the vessel, $Y_i = 3$ if the processor had minority ownership in the vessel, $Y_i = 2$ if the vessel was financed by the processor, $Y_i = 1$ if the vessel owner/operator received a season-end bonus from the processor, and $Y_i = 0$

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[12]The multinomial ordered probit model was developed by Zavoina and McElvey, 1975.

otherwise. Note that each of these categories are mutually exclusive.

Table 6-2: Multinomial Ordered Probit Regression

Log-Likelihood	-19354
Restricted Log-Likelihood	-21536
Chi-Square (8)	4364.4
Level of Significance	3.20E-14

Variable	Coefficient	Std. Error	T-Ratio
ONE	-0.9775	0.0315	-31.05
CAN?	0.494	0.0277	17.81
%DELIV	0.0175	0.0011	15.53
TRAP?	1.203	0.0692	17.39
GILLNET?	0.0737	0.0409	1.80
SEINE?	0.7767	0.0407	19.08
ROUND?	0.203	0.0324	6.27
WEIGHT	4.00E-07	4.00E-08	8.94
TABS	-0.1049	0.0121	-8.67

μ_1	0.2847	0.0071	39.84
μ_2	0.6403	0.0101	63.18
μ_3	0.8792	0.0114	77.32

Table 6-2 summarizes the results of the multinomial ordered probit. The signs of all coefficients are consistent with the thesis' hypothesis. As with the binary probit model, the estimated coefficients reveal the relationship between the explanatory variables and the propensity of a transaction to *ex post* hold-up, Z.

Both probit regressions result in significantly positive coefficients for the variables CAN? and %DELIV. Table 6-3 illustrates the correlation matrix of explanatory variables. There is a strong positive correlation (.617) between the variables CAN and %DELIV; that is, companies that have canning capacity also purchase a high proportion

of landed weight. Despite this correlation, each of the above variables is significant, indicating that they are each important determinants of contractual choice; thus multicollinearity is not a serious problem.

Note that the ordered probit model generates a positive estimated coefficient for GILLNET?, while the binary probit model estimated a significantly, negative coefficient for GILLNET?.. Each of the probit regressions, then, identifies the use of seine or trap gear in the transaction as contributing to the parties' preference for a long-term contract.

The coefficient on ROUND? is also estimated to be positive and significant under both probit regressions. Given that delivered product-form is an accurate proxy for perishability, this lends support to the identification of perishability as an important determinant of contractual choice. Similarly, the regression analyses indicate that the volume of fish exchanged impacts on the parties' preference of contractual choice; specifically, larger deliveries tend to be exchanged under long-term contracts.

Both regressions estimate the coefficient on TABS to be significantly negative. An increase in the number of licences attached to the vessel increases the flexibility of the vessel across fisheries, or reduces the specificity of the vessel to the current transaction. Increased flexibility is thus negatively correlated with the choice of long-term contracts, as is predicted by the thesis' hypothesis.

The estimates of μ_1, μ_2, and μ_3[13] represent the critical cut-off values of (normalized) values of Z. That is, for values of Z in excess of the estimated threshhold, the parties will engage in a transaction involving stronger vertical ties.

The probit analysis generally supports the thesis' hypothesis that contractual choice ultimately depends upon the presence of transaction specific assets in exchanges

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[13]μ_0 has been normalized to $\mu_0 = 0$.

between fishers and processors. In both the binary and multinomial probit analyses, all proxies used to measure asset specificity are identified as significant, with the exception of GILLNET?. This implies that each of the other variables independently contributes to the parties' preference for contractual arrangement.

	CAN?	%DELIV	TRAP?	GILLNET?	SEINE?	ROUND?	WEIGHT	TABS
Table 6-3: Correlation Matrix of Regressors								
CAN?	1.00	0.62	-0.14	-0.01	0.23	0.28	-0.11	-0.14
%DELIV	0.62	1.00	0.04	-0.06	0.21	0.26	0.11	-0.11
TRAP?	-0.14	0.04	1.00	-0.08	-0.12	-0.08	-0.10	0.09
GILLNET?	-0.01	-0.06	-0.08	1.00	-0.67	0.21	-0.21	-0.07
SEINE?	0.23	0.21	-0.12	-0.67	1.00	0.40	0.21	-0.07
ROUND?	0.28	0.26	-0.08	0.21	0.40	1.00	0.07	-0.18
WEIGHT	-0.11	0.11	-0.10	-0.21	0.21	0.07	1.00	0.15
TABS	-0.14	-0.11	0.09	-0.07	-0.07	-0.18	0.15	1.00

CHAPTER 7: CONCLUSION

The purpose of this thesis has been to explain observed contractual arrangements in the B.C. intermediate market for raw fish. Two general classes of contracts have been indentified: spot-market arrangements and incomplete long-term contracts accompanied by non-price compensation. The use of non-price compensation is hypothesized to be motivated by a desire to circumvent the hold-up problem. The potential for *ex post* hold-up arises from the presence of transaction-specific assets in harvesting. Processors undertake *ex ante* credible commitments in order to induce fishers to invest in these transaction-specific assets.

The significance of this thesis is primarily the contribution of the empirical analysis. There has been relatively little systematic empirical work done to test hypt ses of contractual choice that rely on transaction cost approaches. This analysis has objectively measured factors contributing to the proposed explanatory variable (i.e., transaction-specific sunk investments) and assembled a sample of transactions with substantial variation in transactional characteristics. The relationship between observed variations in transaction characteristics was then examined to test whether the predicted relationships between them are in fact observed.

The little empirical work that has been conducted in the area of contractual relations has been largely anecdotal, with the exception of labour contracts. Moreover, most empirical work has focused on examining agents' choices between vertical integration and transactions conducted in the "market". The analysis in this thesis has allowed for the intermediate state between spot markets and vertical integration.

The following variables are identified as contributing to asset-specificity: perishability, volume exchanged per delivery, flexibility of the gear-type across species

and delivered product-form, flexibility of the vessel across fisheries and flexibility of the processing technology across intermediate and final product-forms. Both non-parametric and parametric empirical testing was undertaken in order to test the above hypothesis.

The non-parametric chi-square analyses conducted in Chapter 6 provide strong support for a positive correlation between the presence of asset specificity in transactions and the presence of non-price compensation in transactions. Similarly, the probit regressions undertaken in Chapter 6 are also supportive of a significantly positive correlation between the above variables and contractual choice. Moreover, the ordered probit analysis indicates that asset specificity is positively related the the *strength* of vertical ties in transactions between fishers and processors.

This study also has important implications for the management of commercial fisheries. Understanding the way in which transactors arrive at the rules that are to govern a trading relationship is crucial in markets subject to external management. If fisheries managers are to undertake comprehensive cost-benefit analyses, contractual responsed to proposed regulations must be considered. A natural progression of this research involves an analysis of the effect of fisheries management practises on the nature of contractual arrangements between fishers and processors.

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