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**VERTICAL COORDINATION
IN THE SALMON SUPPLY CHAIN**

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Abstract

The extent of vertical coordination in the supply chain for salmon was limited until the early 1990s. During the last ten years, however, there have been several developments that have led to tighter vertical coordination from salmon aquaculture production to the supermarkets. Most obvious is the rise of large, horizontal and vertical integrated companies, with direct ownership of production activities from hatcheries to fish processing and exporting. But we have also seen the emergence of long-term contractual supplier-customer relationships between aquaculture producing companies and processors or retail chains.

This paper analyses the underlying economic forces driving the development towards tighter vertical coordination in the salmon supply chain and its consequences. Potential incentives for vertical coordination are economies of scale, market or bargaining power, risk reduction, and standards set by governments or private agents in relation to food safety, food quality and environmental effects. First, we present some general findings from the theoretical and empirical literature on vertical coordination in agriculture that is the most relevant for salmon aquaculture. Second, we identify structural differences between agricultural sectors and aquaculture that may lead to different outcomes. Third, we present explanatory propositions on vertical coordination in the salmon supply chain. We provide both theoretical and empirical support for these propositions. Finally, we briefly discuss economic performance and future developments of the industry.

Keywords: salmon aquaculture, supply chain, vertical coordination.

1. Prologue

When salmon aquaculture emerged it first entered the supply chain for wild-caught fish. As a consequence, the salmon industry in the largest producer nation, Norway, adopted many of the prevailing market institutions, product requirements and traditions of the fisheries sector. The market organisation in the supply chain for wild-caught fish has been heavily influenced by inherent characteristics of the production process in fisheries, such as supply quantity uncertainty, quality uncertainty, timing uncertainty and seasonality. These supply characteristics were also present in salmon aquaculture, but to a smaller extent, and through technological innovations that lead to greater control over the production process the aquaculture industry has moved further away from fisheries over time. Aquaculture have most similarities with agriculture, with a mix of controllable and uncontrollable inputs determining output, where uncontrollable inputs such as weather and diseases have a large influence on production outcomes. In Norway, where the government's objective for salmon farming from the late 1970s was a small-scale owner-operator structure as in agriculture, government regulations precluded large-scale vertical and horizontal integration. In addition, the government mandated a producer sales cartel similar to those that are present and protected by law in fisheries and agriculture in many countries. However, these regulations and institutions only survived until the beginning of the 1990s. Following an economic downturn in the industry, when the producer sales cartel collapsed financially, the Norwegian government removed the laws that protected the sales cartel and prohibited horizontal integration at the farm stage.

Technological change in salmon farming, processing and food retailing have increased economies of scale, and in some stages economies of scope, in the salmon supply chain. This has led to increased concentration in several stages. Salmon producers today face buyers, particularly retailers, which are much larger and have more market or bargaining power than were the case before. The average buyer has also become more demanding with respect to product specifications, documentation, regularity and size of deliveries, and transaction costs. In addition, one has seen an increase in standards set by governments and private agents in relation to food safety, food quality and environmental effects. These developments have contributed to increasing the demand for information both upstream and downstream in the supply chain, and for tailoring of production and distribution activities to buyer needs. The nature of production and distribution in several stages of the supply chain create information

asymmetries and moral hazard. This has lead agents in the supply chain to consider different forms of vertical coordination as an alternative to traditional open market transactions.

The extent of vertical coordination in the supply chain for salmon in Europe has been limited until recently. In the last years, however, there have been several developments that have lead to tighter vertical coordination from salmon farms to the supermarkets. Most obvious is the rise of large, horizontal and vertical integrated companies, with direct ownership of production activities from hatcheries to fish processing and exporting. But we have also seen the emergence of long term contractual supplier-customer relationships between aquaculture producing companies and processors or supermarket chains.

The overall picture which emerges is that the salmon farming industry has moved from a model of industrial organisation adopted from traditional fisheries towards a model which has more similarities with manufacturing and the most industrialized value chains in agriculture. However, since salmon farming is a biological production with uncontrollable inputs and inherent production risks, the salmon supply chain has some idiosyncrasies that distinguishes it from a typical manufacturing supply chain.

This paper analyses the underlying economic forces behind the development towards tighter vertical coordination in the salmon supply chain and its consequences. First, we present some findings from theoretical and empirical studies on vertical coordination, primarily from literature that focus on agricultural markets, which is the most relevant for salmon aquaculture. Then, we identify structural differences between agricultural sectors and aquaculture that may lead to different outcomes. Several propositions on vertical coordination in the salmon supply chain are suggested. We provide both empirical and theoretical (although not formalized) support for these propositions. Finally, we briefly discuss economic performance and future developments of the industry.

2. The Economics of Integration and Coordination in Food Systems

This section provides theoretical and empirical explanations for the increased degree of integration and coordination in food supply chains from the economic literature.¹ We first

¹ A 'supply chain' is characterized by the movement and transformation of goods between successive stages of production and distribution. The term 'value chain' is here used interchangeably. The organisation of a supply

discuss briefly issues and key concepts in the general theoretical literature on transaction costs and market coordination, and then focus on the agricultural economics literature on vertical coordination.

The classical works emphasises transaction costs as explanations for vertical coordination and integration. Coase (1937) focuses on the direct transaction costs i.e. the cost of discovering relevant prices, and the costs of “negotiating and concluding a separate contract for each exchange transaction”. If these transactions costs become too large, economic agents will organize their transaction within firms, not through markets. Williamson (1975, 1985), Klein, Crawford and Alchian (1978), Grossman and Hart (1986) and Hart and Moore (1990) introduce what we can call strategic transactions costs i.e. problems of opportunism and relationship-specific investments. Klein *et al.* emphasise the problem of “hold-up”. A party that has invested in specific assets may be forced to accept a worsening of the terms of the relationship after the investment is sunk. Hence, relationship specific investments create appropriable specialized quasi rents. Klein *et al.* claim that vertical integration is more likely the higher the appropriable specialized quasi rents of the assets involved. Williamson emphasises the problem of maladaptation. As the level of complexity, asset specificity and/or transaction frequency increase, disturbances requiring coordinated responses become more numerous and consequential. The high-powered incentives of markets may impede efficient coordination, since both parties want to appropriate as much as possible of the coordination gains. Integration is a way of reducing this kind of maladaptation. Grossman, Hart and Moore formalise the costs and benefits of vertical integration in what has been called the property rights approach. They argue that if assets are complementary, then some form of integration is optimal.

But integration is not the only way to deal with excessive transaction costs and complementary assets. Coordination through contractual solutions can to a certain extent substitute for ownership-integration, even if it is impossible to write verifiable contracts that are fully protected by the legal system. When parties engage in long-term trading relationships, contracts are protected by reputation effects, i.e. the fear of losing future trade. Theorists have shown how such self-enforcing contracts, now commonly termed ‘*relational*

chain encompasses both, at one extreme, independent firms that trade in open markets, and, at the other extreme, fully integrated firms.

*contracts*², can provide ex ante incentives, and ex post safeguards, for specific investments between non-integrated parties (Klein and Leffler, 1981; Garvey, 1995, Halonen, 2002; Baker, Gibbons and Murphy, 2002; among others).

In the food industry we have seen both integration and contractual coordination as a response to direct and strategic transaction costs. But why have these transaction costs emerged? The food supply chain has during the last decades experienced three important trends (Hennessy, 1996): (1) a movement away from undifferentiated agricultural commodities toward more specialized products, (2) a movement toward agricultural industrialization, and (3) reduced dependence on open markets for raw agricultural products.

Primary reasons for the movement away from undifferentiated agricultural commodities on the demand side are the increased demand for more processed food products from the increasing percentage of dual-career and time-stressed one parent families, and the demands for more specialized foods such as low-calorie and ethnic foods. (Barkema, 1993). On the supply side, technological advances have provided the food industry with methods required to deliver highly processed food to the consumer. However, modern food processing often requires raw agricultural inputs with differentiated, specified attributes and a qualitatively homogeneous supply of these inputs. This development has increased the problem of asymmetric information and the need for relationship-specific investments between farmers and processors, which create economic incentives for vertical coordination in the form of contracts or full integration to handle opportunistic behaviour, hold-up and division of coordination gains.

The movement toward industrialisation is taking place through the entire value chain, from the farm via the processing plant to the supermarket. The production process in several types of agriculture can be characterised as 'biological manufacturing', where one uses modern business principles and manufacturing approaches including procurement, inventory management, and process control technologies (Boehlje, 1999). Food processing is characterized by increasing capital intensity and economies of scale (MacDonald and Ollinger, 2000; Paul, 2001a; 2001b). This has led to a growing focus on capacity utilization, and has also contributed to an increased plant and firm concentration in food processing (Barkema, Drabenstott and Novack, 2001; Rogers, 2001). At the retail level both individual

² Relational contracts are also called 'implicit' contracts (e.g. MacLeod and Malcolmson, 1989).

stores and supermarket chains have grown in size. This can be explained by increasing economies of scale and scope in logistics and distribution. Wholesaling and distribution has been integrated by many retailers to take advantage of these economies. Furthermore, the adoption of electronic point of sale (EPOS), electronic funds transfer systems (EFTPS) and electronic scanners have greatly improved the efficiency of distribution and stocking activities, with needs being communicated almost in real time to supplier (Clarke *et al.*, 2002, pp. 152-3). Today, retail chains rank among the largest companies in the world, and several are multinational with operations in European countries and North America. Retailers seek to brand their chains creating differences from their competitors, moving away from price as the only measure of competitiveness. They are able to influence the specification and production of merchandise. Furthermore, the share of private label products has increased over time (Bell, Davies and Howard, 1997).

Food quality problems can occur because substandard food is produced at a farm and is not primary-sourced thereafter. Hennessy (1996) demonstrates that a price-grade type incentive structure will cause a systematic underinvestment in food quality at the farm stage when there is uncertainty in the grading and testing mechanisms. Such uncertainty exists because of sampling and measurement errors. Many tests identify only proxies or indicators of the attribute that is of interest. An example is pesticide residues. Concerns about methods used to detect residues have been expressed by, for example, US government agencies.³ One study suggests that pesticide residue measurement errors may be in the order of 200% or more. This comes in addition to the fact that sample residues may not be representative of average levels. An information failure like this gives rise to a downstream firm (e.g. processor) incentive to circumvent test cost by vertically integrating or sourcing via contracts.

3. The Case of Salmon Aquaculture

This section provides an analysis of vertical coordination in the value chain for farmed salmon. Since the early 1990s there has been a development towards a higher degree of vertical coordination. In the following we try to explain the underlying forces behind these developments, and why modes of vertical coordination in the salmon industry differ from

³ See Hennessy (1996) and references cited therein.

other food producing sectors. We present several propositions on the underlying forces behind the process towards increased vertical coordination.

The supply chain for fish has traditionally been characterized by high flexibility due to the seasonality and randomness of raw product availability from fisheries. Fishers have been used to periods of idleness and have often had onshore work as additional or main source of income. In fish processing adjustment of labour input through temporary or permanent layoffs has always been a regular phenomenon. The market also accepted a seasonal and uncertain supply of wild-caught fish. Furthermore, fish has traditionally been supplied to consumers in a limited number of product forms that allowed for long-term storage, and thus smoothing out of consumption over longer time periods than the fishing seasons. However, due to far-reaching structural changes both on the supply and demand side, the old fish supply chain regime is being replaced with a new one. Aquaculture, which has grown rapidly over the last decades has provided the possibility for a much higher degree of control with the timing, quantity and quality of raw product supply than conventional fisheries. In fish processing labour is being replaced with capital equipment, leading to increases in economies of scale and more focus on capacity utilization. At the downstream end of the supply chain, retail chains have much larger requirements to fish product supply than traditional fish buyers in terms of timing, regularity, quantity and quality. Retailers, which in the 1980s bought less than half of farmed salmon, now purchase 60-90% of the salmon in many European countries. Finally, consumers are increasingly demanding fresh fish, but also a large variety of processed fish products. These developments have all contributed to an industrialisation of the fish supply chain.

Most state-of-the art contributions in this literature focus on US agriculture. Although there are many similarities between US agricultural sectors and salmon aquaculture, one can also find some notable differences. First, fish is generally more perishable than agricultural food products which are often studied, such as poultry meat, pork, and beef. Hence, fish requires larger investments and higher degree of coordination in the supply chain in order to preserve product quality and increase shelf life. Second, it may be more costly to monitor external inputs in the production process in offshore aquaculture than in agricultural production processes. Furthermore, vertical coordination in the supply chains examined in the literature is primarily intra-country, typically between domestic US companies. Salmon, on the other

Table 1. Companies ranked by global production in 2003 of salmon and sea trout (in metric tonnes)*

Nr	Company	Head-quarter	Total 2003	Norway	UK	Chile	Canada	USA	Other countries
1	NUTRECO	Netherlands	178,500	70,000	32,000	59,000	12,500		5,000
2	PAN FISH	Norway	86,100	31,100	20,500		9,800	12,000	12,700
3	FIORD SEAFOOD	Norway	72,500	35,000	7,000	28,000		2,500	
4	STOLT SEA FARM	Norway	70,500	15,000	6,000	24,000	25,000	500	
5	CERMAQ	Norway	48,500		8,000	32,500	8,000		
6	AQUACHILE	Chile	48,000			48,000			
7	PESQUERA CAMANCHACA	Chile	37,000			37,000			
8	CULTIVOS MARINOS CHILOE	Chile	34,500			34,500			
9	SALMONES MULTIEXPORT	Chile	34,000			34,000			
10	PESQUERA LOS FIORDOS	Chile	33,000			33,000			
11	GEORGE WESTON/CONNORS	Canada	28,500			8,500	19,000	1,000	
12	SCOTTISH SEAFARMS	UK	23,000		23,000				
13	SALMAR/SENJA SJØFARM	Norway	21,000	21,000					
14	INVERTEC	Chile	20,300			20,300			
15	SJØTROLL	Norway	20,000	20,000					
16	PESCA CHILE	Spain/Chile	20,000			20,000			
17	NYE MIDNOR	Norway	19,000	19,000					
18	AGUAS CLARAS	Chile	18,000			18,000			
19	SEAFARM INVEST / HØLLALAKS	Norway	16,000	16,000					
20	HYDROTECH-GRUPPEN	Norway	15,000	15,000					
Total production top 20			843,400	242,100	96,500	396,800	74,300	16,000	17,700
% of total production			56%	42%	60%	85%	67%	75%	12%
Total			1,493,005	583,100	160,000	465,205	110,700	21,200	152,800

* Sea trout is very similar to salmon w.r.t. production technology and product characteristics.

hand, is mostly traded internationally and traded over longer longer distances than meat from agriculture.

There is plenty of evidence of vertical integration in the salmon supply chain. Other forms of vertical coordination, such as long-term contracts are less visible, because their existence or information about contract specifications usually are not made public by the contracting parties. However, there is plenty of anecdotal evidence on the existence of contractual relationships, and also some information on contract specifications. Although the transition towards increased vertical integration has been driven primarily by firms upstream in the supply chain, the picture is somewhat mixed. Table 1 presents the largest salmon companies and their farm production of salmon in various countries. The Dutch company *Nutreco*, which is the world's largest producer of salmon, as shown in Table 1, initially owned a company that produced feed for salmon. It has later bought salmon farming firms in several countries, and has expanded into processing of salmon. Interestingly, Nutreco has chosen a different model of vertical organisation in agriculture, where it owns companies that supply feed, chicken and piglets to poultry and pig farms, and also owns processing companies, but has no ownership in farms. The Norwegian company Pan Fish (second largest salmon producer) owns plants that produce smoked salmon in Denmark and France. The Norwegian company *Fjord Seafood* (third largest salmon producer), which initially focused on salmon farming, has integrated downstream through its purchase of the Belgian fish processor *Pieters*.

3.1. Empirical Propositions on Vertical Coordination in the Salmon Supply Chain

In the following we present some propositions on vertical coordination in the salmon supply chain which we provide both empirical and theoretical support for.

Proposition 1. Only recently has there been an economic rationale for the salmon aquaculture industry to shift its focus from primary production to activities further downstream and increased vertical coordination as means to increase economic return.

Producers that are under pressure from competitors or owners asking for higher returns are constantly searching for new technologies, production practices or product modifications that can reduce costs and increase profits. For a profit-maximizing firm or industry it is rational to focus on areas where the largest gains can be made. In the early days of salmon farming this

was obviously at the grow-out farm stage of the value chain, since essential technologies were rather ‘primitive’ in relation to the potential promised by the most sophisticated analogous technologies in agriculture and the opportunities in exploiting information technologies and biotechnologies. Through adoption of new technologies and learning, the salmon industry managed to reduce the costs of production dramatically, as has been documented by e.g. Asche (1997) and Tveteras and Heshmati (2002).

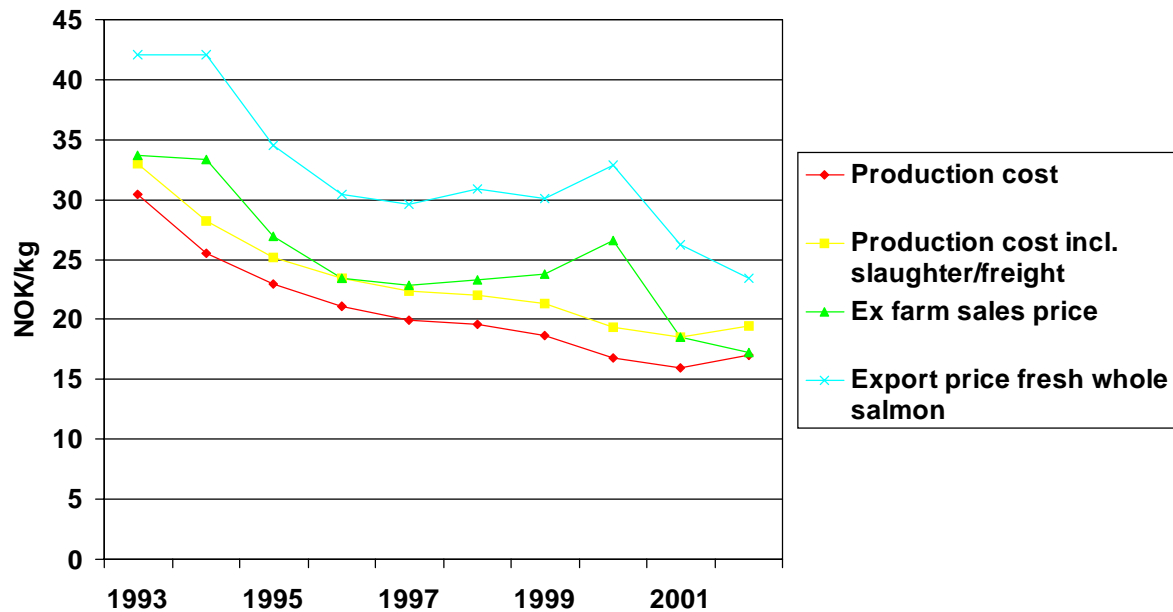


Figure 1. Real prices and production costs in Norwegian salmon farming (2002=100, Source: Directorate of Fisheries, Norwegian Seafood Export Council)

Figure 1 shows the development in production costs and prices in Norwegian salmon farming. We see that production costs declined rapidly up to 2000, but have thereafter stabilised. After some of the most obvious sources of cost reduction had been exhausted at the farm level, attention seem to have gradually shifted more to other stages further downstream in the value chain, particularly processing and distribution to customers. This shift of focus coincides with a trend toward increasing customer demands with respect to product quality, and adaptation to their standards and procedures for purchasing and product documentation.

Proposition 2. *Increasing economies of scale and operating capital requirements together with a substantial economic risk have lead to horizontal integration at the farm production*

stage. Increased horizontal integration has subsequently contributed to forward and backward vertical coordination.

The increasing degree of horizontal integration in salmon farming is an important element in the understanding of the vertical coordination process in the salmon supply chain. Salmon farming is characterised by a considerable production and price risk (Tveteras, 1997, 1999, 2000; Asche and Tveteras, 1999). The production period from release of salmon fingerlings to harvest is typically 12-18 months. During this period the biomass of live fish is exposed to diseases, temperature changes, and extreme weather conditions. Salmon market prices can change significantly during such a time horizon. The Norwegian salmon industry was originally an owner-operated industry, with many hundred small single-plant (or single-farm) firms. After the Norwegian authorities relaxed their regulations on horizontal integration in salmon farming in the beginning of the 1990s, a mergers and acquisitions process started that changed the industrial structure significantly. Several hundred farms were integrated into larger companies. An explanation for the exit of small entrepreneurs from the industry is probably the combination of large operating capital requirements, an imperfect capital market that discriminates against small entrepreneurs, and substantial economic risk.⁴ Salmon farming entails an economic risk of a magnitude that many small entrepreneurs were not willing or able to carry over many years.⁵

As salmon farming companies have grown, the potential gains from different forms of coordination with suppliers and buyers have increased. Salmon farming companies often operate many farms in particular regions, and have subsequently become large and dominant buyers of inputs and producer services in these regions. This has made it possible for them to exercise market or bargaining power for some inputs. It has also opened up for a higher degree of coordination with suppliers (of fish feed, fish transportation services, veterinary services, maintenance services, etc.), leading to a more efficient use of resources. The main sources of productivity increases through increased vertical coordination are (1) outsourcing of tasks leading to increased labour specialization, (2) outsourcing leading to investments in

⁴ The value of the capital equipment and live fish in the cages at the smallest salmon farms (12.000 m³ cage volume) will typically be around 5-7 mill. NOK and 7-10 mill. NOK (1 EURO = 8 NOK), respectively. For a small entrepreneur this entails a considerable capital cost, and also a large economic risk, as much of the live fish stock could potentially be wiped out by diseases, and market prices could drop substantially during a 12-18 month production period.

⁵ Econometric estimates indicate that salmon producers are generally risk averse (Kumbhakar and Tveteras, 2003).

specific and highly productive capital equipment, (3) increased degree of planning between suppliers and buyers.

Together with suppliers of producer services a salmon farming company can plan and organise the provision of these services to the farms so that productivity is increased, and thus costs are lowered, for the supplier or the salmon farming company, or both. Inputs and producer services can be provided with different qualities. Some salmon farming companies may demand a higher quality of producer services and inputs than other, for example, because they serve customers or market segments with particular requirements to the production process or product. However, relation-specific investments sometimes may have to be undertaken to reduce costs or increase quality, e.g., in equipment and specialised human capital that cannot be supplied easily to other buyers in other regions due to high transportation costs or low mobility of human capital. Other salmon farming companies may also not demand the same high-quality inputs because of differences in the production technology and organisation, or because they serve buyers with smaller product requirements. Relationship-specific investments open up for vertical coordination through long-term contracts, or for vertical integration, due to the possibility of opportunistic behaviour from one or both parties after relationship-specific investments have been made.

Thin regional markets for specialised producer services to salmon farms, which has been reinforced by increasing firm concentration, has lead banks to demand some evidence that a supplier has a customer base before they are willing to lend money for investments in capital equipment and human capital. For suppliers this has provided an incentive to enter into contracts with salmon farming companies. Since investments can increase productivity and reduce costs for the buyer too, salmon farming companies have ‘assisted’ suppliers by entering into a long-term relationship before the supplier had obtained funding from banks for these investments.⁶

In some cases it may also be difficult or costly to observe the quality of inputs for the buyer. This is, for example, the case for salmon fingerlings, which are reared at different locations than the grow-out farms. As predicted by theory, one observes widespread vertical integration between salmon fingerling production and salmon grow-out farms. Empirically, one finds that salmon farming companies choose different types of coordination with suppliers of a

particular input or producer service, ranging from spot market purchases, via long-term contracts, to in-house provision (or vertical integration). Different choices for a specific input may be explained by internal characteristics of the company and by regional market conditions. However, the trend is clearly one of increased coordination in input markets.

As salmon companies have grown, so has also their economic risk exposure measured in absolute value. Risk averse producers would have an incentive to enter into contracts with buyers that can reduce their income risk, depending on the cost of risk reduction.⁷ Furthermore, larger salmon companies will also be more able to enter into contracts, which often are demanded by large buyers, such as retail chains, and therefore entail deliveries of large quantities of fish.

Vertical integration may be an even more efficient a response to widely varying supply prices than contractual coordination. This even in risk-neutral environments. Baker, Gibbons and Murphy (2002) propose a solution to the puzzle noted by Carlton (1979): why would risk-neutral companies pursue vertical mergers to achieve certainty of supply? They show that ownership integration can reduce the temptation to renege on relational incentive contracts when supply prices vary, which is certainly the case for farm gate salmon prices. Under non-integrated ownership, an extreme realization of supply prices creates a large temptation to renege on a relational contract. This renegeing temptation limits the incentive power of the best relational contract that can be implemented under non-integrated ownership. Under integrated ownership, however, the renegeing temptation is independent of the supply price, making integration the more efficient governance structure when the supply prices vary widely.

Proposition 3. *Changes in primary fish processing⁸ technologies have provided economic incentives for increased coordination with both suppliers of raw salmon and buyers of processed salmon products.*

Traditionally, the fish processing industry has been dependent on raw product supply from fisheries. The seasonal and random nature of this supply has forced processors to choose

⁶ There is anecdotal evidence of salmon farming companies behaving in this way from Norway.

⁷ Only a few of the largest salmon companies are listed on stock exchanges and have, at least a minority of, well-diversified share owners. Most companies have owners who have invested much of their capital in salmon farming, and may therefore be inclined to reduce their risk exposure.

⁸ Primary fish processing includes slaughtering, filleting and packaging processes.

flexible ways of organising the production. This includes flexibility in hiring and firing of (low-skilled) labour, and use of relatively labour-intensive production technologies which reduced the opportunity cost of idle capital equipment in periods when fish was not available. Over time a host of processing technologies has become available that can replace labour in processes such as sorting, gutting, skinning, bone removal, slicing and portioning. As relative wages for low-skilled labour in Europe has increased over time, and it has become more difficult to recruit and keep workers, the incentive to substitute labour with capital equipment has become stronger. Primary processing plants for salmon are generally located in coastal areas with thin regional labour markets, where it is often difficult for employers to recruit and keep employees unless they can provide relatively stable earnings and a satisfactory work environment.⁹ New government standards and buyer requirements on food safety and sanitary conditions have increased the need for a stable workforce, since it is necessary to undertake investments in training.

The main barriers to substitution of labour with capital have been that new technologies entails high fixed capital user costs and increased the optimal (i.e. minimum efficient) scale of production. For a salmon processing plant that primarily carries out slaughtering and packaging operations, the optimal scale has increased from around 10.000 tonnes of live fish per year to more than 30.000 tonnes per year.¹⁰ This means that the number of standard size salmon farms, which each typically produces around 700 tonnes, that are needed to supply a single processing plant has increased from around 14 to more than 40.¹¹

Thus, processors have become more dependent on a large and steady supply of raw material to keep costs down. Aquaculture has, however, opened up the possibility for exploiting the scale economies in new processing technologies. In salmon farming the ability to supply live salmon throughout the year has increased over time. Processors can in principle purchase the salmon in a spot or cash market. However, due to relatively high transportation costs for live salmon from farms to processing plants, the relevant raw fish input market is regional. In Norway, each of the nine coastal regions (counties) with salmon farming has from 50 to 150 farms. With increasing firm concentration and vertical integration, the regional markets for

⁹ See, e.g., an article by Terje Marøy in the trade journal *Fiskaren*, 2. May 2003, p. 12-13, for anecdotal evidence on the difficulties of recruiting and keeping workers in salmon processing plants.

¹⁰ See, e.g., an article by Kjerst Sandvik in the trade journal *Fiskaren*, 14. August 2002, p. 6.

¹¹ A standard salmon farm has a licensed cage volume of 12.000 m³, and is subject to a government fish feed quota which limits production to around 700 tonnes.

live salmon have become thinner over time. This represents a challenge for both the farms and the processors. In the worst case farms may face a regional processing monopsony or duopsony. Processors, on the other hand, may face several regional suppliers, but still not enough to ensure a steady weekly supply of fish with the right attributes. Within a region, defined by the relevant transportation distance from farms to processing plant, there will typically be from a handful to twenty firms that owns all the farm stage production capacity. This applies to most producer countries.

There are also transaction costs in the market for live salmon. Barkema and Cook (1993) identified *search cost* and *risk cost* as two transaction costs that could be reduced through increased vertical coordination. For the processor, risk cost is associated with fish not arriving on time, in incorrect quantities, or with physical (quality) characteristics (e.g. size, freshness, colour, fat content) which increase processing costs or reduce sales value. As processors over time have developed more narrow specifications for acceptable raw products, due to demands from customers, government requirements and technological changes (e.g. transition from manual to machine-based processing), their risk cost has increased. The physical characteristics of salmon are costly to measure prior to harvesting. For a processor there are significant search costs associated with finding fish farmers that can supply fish with the right specifications in sufficient quantities and at the right times to ensure a high capacity utilisation.¹² This has contributed to the development of increasing long-term vertical relationships between salmon farms and processors by means of long-term contracts or, increasingly, through full vertical integration. Through integrated planning of production schedules, and the use of a specified set of inputs (feed, medicines, etc.) and production routines on all fish farms, supply to the processor is ensured.

In order to ensure full capacity utilization the primary processor is dependent on a steady demand through the year for its products from secondary processors (e.g. salmon smokers), exporters, retailers or other downstream buyers. A spot market may not provide this. A long-term relationship between the processor and its buyers may be beneficial to both parties. Long-term relationship with one or more buyers that accept to take certain (minimum)

¹² Processors of other foods face similar challenges. For example, in the beef packing industry economies of scale and the variability of weekly supply provide the packing company with incentives to extend control over cattle supplier back toward the producer as to ensure optimal flow through its operation lines (Ward; Jensen, Kehrberg and Thomas).

quantities at specified time intervals facilitates vertical coordination in production planning from fish farming to processing. If such planning leads to a more optimal use of resources (i.e. lower costs) or higher product quality the benefits can in theory be shared between the buyer and seller. When buyers have specific or non-standard requirements with respect to the product or the production process that includes production activities before processing, then some form of vertical coordination between farm and processing stages usually becomes a necessity.

Proposition 4. *The growing share of salmon bought by increasingly demanding food retailers has been a major driving force in horizontal and vertical coordination.*

In Europe and North America the size of food retail chains and firm concentration has grown substantially since the salmon farming industry was established around 1980. Large retailers exert considerable bargaining power towards suppliers when they have a large (and together with a few other retailers a dominant) market share in national markets, and are present in several countries. As salmon abandoned its status as an exclusive, luxury good, the share of salmon sold through food retail chains has increased significantly, and salmon is now typically the most important fish species in supermarket in terms of sales volume.¹³ Food retail chains are in many respects the most demanding buyers that the salmon supply chain faces. These demands include several supplier attributes, such as product price, volume, logistics costs, regularity of supply, supply security, product attributes (e.g. size, fat content, colour, omega-3 content), shelf life, production process (e.g. raw materials in fish feeds, environmental impacts, animal welfare, procedures), product range, documentation, and traceability (Anon., 2001a, 2001b; Richardson, 2002).¹⁴ Table 2 provide a summary of the demands that salmon suppliers face from retailers. Of course, there is substantial variation across retail chains with respect to the importance of these demands. For example, hard discounters may focus less on product processes and raw materials than hypermarket chains that serve more (quality-)conscious consumers.

Some of these demands are related to food safety, which will be discussed more in a later proposition. Food retail chains may also have their own quality labels that impose product and

¹³ See, for example, Murray and Fofana (2002), for an analysis of changes in fish retailing in the UK.

¹⁴ In addition to cited references, information on retail chain demands have been provided to us through direct interviews with salmon suppliers (Tveterås and Dybvig, 2003).

production standards on suppliers. For example, the multinational retail chains Auchan and Carrefour both sell salmon under own quality labels.

Table 2. Buyer demands to suppliers of farmed salmon

1	Price	(a) Price level, (b) linkage to market prices, (b) quantity discounts.
2	Volume and timing	(a) Total volume, (b) regularity of deliveries, (c) flexibility in deliveries, e.g. in relation to "normal" volumes and times of delivery.
3	Raw material attributes	(a) Size distribution, e.g. fillets, (b) quality attributes, e.g. colour, fat, texture, taste, (c) fresh vs frozen, (d) uniform quality, (e) shelf life.
4	Product range and differentiation	(a) Fish species, (b) Product varieties, e.g. easy-to-cook, ethnic foods, healthy foods, (c) private labels / brands, (d) consumer advertising.
5	Production process	(a) Raw materials in feed, (b) environmental effects of production, (c) animal welfare, (d) third party certification, e.g. ISO, EMAS, (e) traceability.
6	Transaction costs	(a) Negotiation, (b) planning, (c) control and enforcement, (d) transportation og (e) storage.

Clearly, the salmon farming industry with the structure it had around 1990 could not have been able to satisfy the current demands from large food retail chains. Some of the long-term contractual relationships that retail chains have entered into for salmon products, are with large vertically integrated companies that own production activities from farming to processing. But long-term contracts are also found for non-integrated but coordinated salmon supply chains. An example is the multinational retailer Carrefour's contractual relationship with a supply chain including independent salmon farming companies such as Aqua Farms and export companies such as Hallvard Lerøy and Ålesundfisk, where salmon is marketed under the 'Filières Qualité Carrefour' label (Anon., 2001; Richardson, 2002). Although it is difficult to get access to many details from these supplier-customer relationships and contracts, the empirical evidence we have suggest that all the supplier attributes mentioned above are to a varying degree taken into account in the contract or in other aspects of the

supplier-customer relationship not covered by the contract. Contracts may specify verification mechanisms, such as an initial certification of hatcheries, farms and processing plants by an independent third party, and revisions at regular time intervals.¹⁵

Proposition 5. *The share of salmon that is handled by intermediaries (exporters, importers, wholesalers, etc.) shrinks as firm size and concentration increase both upstream and downstream.*

Traditionally, fish farmers generally focused on production and sold the salmon to intermediaries such as export companies. Under some circumstances, intermediaries may have advantages over direct exchange.¹⁶ When the salmon farming industry consisted largely of small, often owner-operated, firms, with a small production volume to sell in the international market and limited internal resources beyond farm production, intermediaries clearly had a role to play. Intermediaries such as export trade companies reduced transaction costs due to their specific competence and economies of scale in the functions they performed, pooled and diversified risk through buying salmon from many farms and selling to many different buyers and national markets, and reduced costs of matching and searching due to their presence in markets and repeated transactions with salmon farms and buyers. Following large-scale horizontal integration the salmon producing companies have themselves taken over sales and distribution functions that were earlier provided by intermediaries. They have recruited highly specialised and educated employees and set up affiliates abroad, and distribute fixed costs in international distribution and marketing over a large production volume. At the downstream end of the value chain, the size of the typical buyer company has increased as the share of salmon sold to the retail segment has increased, and one has seen increased concentration both in this market segment and other segments that salmon is supplied to. Many of the middlemen in the supply chain have been eliminated and their margins absorbed. Retailers have invested in dedicated distribution depots, which bypass the function of the traditional wholesaler. The influence of wholesale markets such as

¹⁵ Parts of contracts may be commercially sensitive, and it is therefore difficult to obtain information on all details, and obtain permission to publish contract information. We have collected contract information both through open sources and direct interviews. See, for example, Anon. (2001a).

¹⁶ The advantage of intermediaries may be related to (1) reducing transaction costs, (2) pooling and diversifying risk, (3) lowering costs of matching and searching, (4) alleviating adverse selection, (5) mitigating moral hazard, and (6) supporting commitment through delegation (Spulber, 1999, p. xiii).

Smithfield (London) and Rungis (Paris) have declined in inverse proportion to the growth of retail chains (Bell, Davies and Howard, 1997).

Proposition 6. *The fact that salmon is mostly traded internationally provides an additional incentive, but also additional barriers, for vertical coordination in the form of long-term supplier-customer relationships.*

There is generally a lack of transparency in food supply chains, and this is particularly the case for trans-boundary supply chains. Different languages, traditions in production and consumption, legal systems, and standards are some of the potential barriers. Buyers may have less knowledge or be more uncertain about foreign companies' production processes, e.g. with respect to use of raw materials and environmental impacts, than those of domestic companies. On the other hand, sellers may have limited knowledge about country-specific market conditions, e.g. the importance of different food product attributes for consumers. Hence, the need for specific investments, but also the scope for moral hazard may increase in international relationships. If purchasers have particular demands with respect to product attributes and production processes, which are costly to observe, then different national locations of different stages of the value chain can provide an extra impetus for vertical coordination through integration or long-term contractual relationships, because traditional trust systems do not work well across national borders.

However, it may be more costly for two parties from different countries to specify contracts due to language barriers, different legal traditions, and different laws and regulations. Thus, the problem of incomplete contracts may be larger in international than in domestic supplier-buyer relationships. In market segments where the need for vertical coordination is more marginal, contractual relationships may not be realised due to high contract specification and enforcement costs. It is also possible that firms choose to integrate vertically across countries instead of entering into a contractual relationship in some cases where it is necessary to have a high degree of coordination with production or marketing functions abroad, but it is difficult to specify complete contracts.

Proposition 7. *As the share of value added salmon products grows, the incentives for vertical coordination, through vertical integration or long-term contracts, become larger.*

The range of value added salmon products have increased over time. There is generally less substitutability between value added products than fresh unprocessed salmon from different suppliers. The incentive for long-term buyer-supplier commitments may increase due to:

- large, specific investments in product development, packaging, advertisement, etc. When a processor has invested in a branded product line that is marketed through e.g. a large retail chain, it may be difficult or costly to get other retail chains that carry competing brands to switch brand. Consumers often expect to find a certain brand at their store, and may not switch easily to a new brand. Thus, also for a retailer may the exit of a brand be costly, although generally less than for processors, which tend to be more dependent on a few products. In several countries a value-added product such as smoked salmon is often marketed under retailers' own private labels. For the processor the sales share of the private label of a particular retailer will often be very high, maybe well over 50%. Under such circumstances the loss of a private label contract can lead to large losses for the processor.
- specific investments in fish processing facilities. A fish processor's optimal choice of production scale, equipment and location will often depend much on its customers. In general, factors such as tariffs and market knowledge will often favour investments in facilities close to the buyers. If the seller-buyer relationship is terminated, then the processing facility may be far from optimal in relation to other buyers.
- greater need for stable prices to consumers for value added products. Consumers typically expect fairly stable prices on branded products. This is a problem if the cost share of the raw fish product is large, because the processor and its buyer will often not accept large fluctuations in the primary product prices. A risk averse processor which is not diversified will have strong incentives to enter into long-term arrangements that can secure relatively stable prices for an important input (e.g. live or less processed fish).

Proposition 8. *Increased focus on food safety is affecting salmon to at least the same degree as agricultural livestock products, and provides additional incentives for vertical coordination.*

An increasingly important risk cost downstream in the value chain is unobserved characteristics of the production process or product which consumers learn or perceive as detrimental to their own health, unsustainable, or unethical. For a large retail chain an incident related to one food item could potentially have substantial economic costs if there are

spillover effects to its general reputation, leading consumers to reduce their purchases of the thousands of products that the retail chain carries in thousands of stores.

Consequently, in addition to the legislation introduced by governments to protect consumers from unsafe food and the environment, retail chains have developed their own private standards and imposed product and production process documentation requirements on suppliers of salmon.

Salmon is farmed in several countries. The level of pollution in the marine environment that the salmon is subject to may vary both across and within countries. Moreover, salmon aquaculture uses inputs in fish feeds purchased globally, such as soy meal, rape seed oil, fish meal and fish oil. These inputs are produced in South America, North America and Europe. Concerns include high dioxin levels in fish oil, low omega-3 levels due to substitution of fish oil with vegetable oil, and use of genetically modified soy meal from North America. Depending on destination country and market segment, concerns with respect to production conditions and input use have to be addressed by suppliers of farmed salmon. Transparency and traceability have become important issues for many buyers of salmon. Some salmon companies now provide product guarantees and a system of documentation with respect to dioxin levels, absence of genetically modified inputs, etc.¹⁷ This is costly and often requires vertical coordination of information flows across several national boundaries.

4. Structural Changes and Economic Performance

Global salmon production has expanded more or less continuously over the preceding 20 years. This has largely been driven by productivity increases which have allowed for profitable expansion despite a significant price reduction. Since the late 1980s Chile has increased its market share at the expense of Norway and other producer countries. This can largely be attributed to Chilean producers' ability to adopt state-of-the-art technologies and exploit economies of scale in farm production and primary processing (Tveterås *et al.*, 2004).

¹⁷ See, for example, the web home page of the leading salmon companies *Nutreco* (www.nutreco.com) and *Fjord Seafood* (www.fjord.com) for more information on their policies on food safety and traceability systems.

At the firm level the economic rationale for organizational restructuring and choosing different modes of coordination with suppliers and buyers is to increase expected economic returns and reduce economic risk. It is difficult to measure the effects of the structural changes we have discussed in this paper since there is a great diversity of organizational choices among firms, and since data at the firm level are not readily available. But it is possible to provide some observations on the relationship between organizational choices and economic performance.

One of the key developments in the salmon industry has been the horizontal integration at the farm stage. Figure 2 shows the cost of production at the farms stage of firms grouped by size.¹⁸

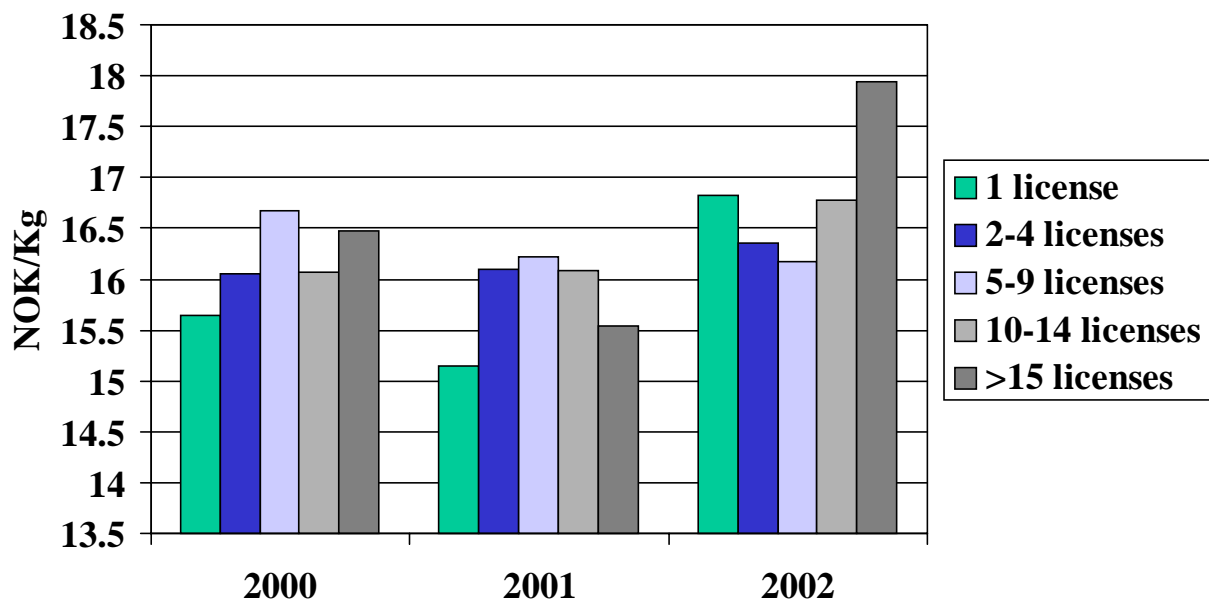


Figure 2. Production costs in salmon farming by size of firm in Norway (Source: Norwegian Directorate of Fisheries)

We see that the larger firms are not more cost efficient than smaller firms. It has been argued that a biological production such as salmon farming requires motivated workers and managers with an economic stake in the production outcome (Tveterås, 1999). A study by Tveterås & Dybvig (2003) found that only a third of 21 large salmon companies in Norway had economic incentive schemes for their farm employees in 2003. The share of companies with incentive schemes was probably even smaller in previous years. This leads one to conclude that what

¹⁸ A production license measures the total volume of water in the cages and allows for a production of around 7-800 tonnes.

may have been gained by integration through exploiting economies of scale may have been lost through a lower worker and management performance.

It is difficult to obtain data on the economic performance of the downstream stages of the value chain which enables one to examine the effects of organizational choices. For the large, vertically integrated companies the annual reports provide information on economic returns, but it is usually the overall performance which is reported. A study of common accounting measures of economic performance provides a mixed information of large companies relative to smaller companies. There are also several sources of 'noise' in the financial data. A large number of salmon farming companies were acquired at a high price by the larger companies in the late 1990s and 2000 on the expectation that high salmon prices would prevail in the future. The high cost of acquisition has depressed economic return to capital for several companies in the subsequent years. Nevertheless, one can argue that the large, vertically integrated companies have so far not provided a superior economic performance compared to the smaller firms. To some extent this can probably be explained by the costs of learning and adjustment. The transition from small firms to large companies requires huge changes in the skills of managers at several levels, implementation of systems that facilitates the coordination of activities, changes in job descriptions, elimination of redundant employees and departments, etc.

It is hard to find support for a hypothesis that the largest salmon firms have benefited from market power. The degree of firm concentration (cf. Table 1) has not reached levels that should give concern for the overall market. For the largest companies it may even be hard to shut out intermediate sized companies in the retail chain segment, where individual chains buy large quantities of salmon. The biggest retail chains could in theory be supplied by a single salmon company, but will usually avoid overly dependence on one supplier. This creates opportunities for companies of intermediate size or for strategic alliances of smaller companies, as have been observed for some of the largest retail chains (e.g. Carrefour).

5. Implications and Future Developments

Vertical coordination and integration in the salmon supply chain have been caused by technological and information characteristics of production and distribution processes, both upstream in farming and downstream in retailing.

Horizontal and vertical integration has probably improved welfare in the European salmon market, due to risk reduction and increased coordination between successive stages of the value chain which have led to lower supply cost to consumers and increased levels of food quality and safety assurance.

There is no evidence that the increased firm concentration in salmon farming has led to non-competitive pricing of farmed salmon. Relative to production costs, farm prices have decreased since the peak in 2000. As for the food sector in general, the salmon industry has a need to counteract retail buyer power through changes in its industrial organization.

Horizontal and vertical integration has reduced some economic risks in the salmon supply chain. Since producers have been found to be risk averse this has led to a welfare improvement, as risk averse producers tend to make input and output decisions that deviate from socially optimal decisions.

The salmon companies predominantly pursue specialization through a single-species strategy. Recently one has seen the expansion of large multi-species seafood companies in Europe and North America, which source several fish species from both fisheries and aquaculture using different forms of coordination with the primary production stage, but with a focus on downstream distribution and marketing. A central question is if the single-species strategy is economically viable in the future or if there are significant economies of scope in distribution and marketing related to sourcing several fish species? A potential competitive advantage of the multi-species seafood companies is the potential to distribute investments in marketing and distribution over a large volume encompassing several species. These companies have the potential to develop intangible assets downstream in the value chain related to market research capabilities, market knowledge, product development, brands, and efficient distribution systems. Such assets characterize the largest corporations in the food industry.¹⁹ The question is if the vertically integrated salmon companies in the future can create similar assets on the basis of one species, or if we in the next phase in the salmon industry may see the merger with other species in some stages of the supply chain.

¹⁹ E.g., the companies Nestle, Unilever and Kraft Foods.

References

- Anon. (2001a) "The Customer Wants to Know Everything" (In Norwegian: "Kjøperen vil vite alt"), *På Mærkanten*, No. 5, 12-13
- Anon. (2001a) "Fish with Fingerprints" (In Norwegian: "Fisk med fingeravtrykk"), *På Mærkanten*, No. 6, 12-13
- Asche, F. (1997) "Trade Disputes and Productivity Gains: The Curse of Farmed Salmon Production," *Marine Resource Economics*, 12, 67-73.
- Asche, F. and R. Tveteras (1999) "Modeling Production Risk with a Two-Step Procedure", *Journal of Agricultural and Resource Economics*, vol. **24** (2), December, pp. 424-439.
- Baker, George, Robert Gibbons and Kevin J. Murphy. 2002. "Relational Contracts and the Theory of the Firm." *Quarterly Journal of Economics*, **117**: 39-94
- Barkema, A. (1993) "Reaching Consumers in the Twenty-First Century: The Short Way Around the Barn." *American Journal of Agricultural Economics*, **75** (December), 1126-31.
- Barkema, A. and Cook, M.L. (1993). "The Changing U.S. Pork Industry: A Dilemma in Public Policy." *Economic Review*, Federal Reserve Bank of Kansas City, Second Quarter 1993, 49-65.
- Barkema, A., Drabenstott, M., & Novack, N. (2001). "The New U.S. Meat Industry." *Economic Review*(2nd Quarter), 33-56.
- Bell, R., Davies, R., & Howard, E. (1997). "The Changing Structure of Food Retailing in Europe: The Implications for Strategy." *Long Range Planning*, **30**(6), 853-861.
- Boehlje, M. (1999). "Structural Changes in the Agricultural Industries: How Do We Measure, Analyze and Understand Them?" *American Journal of Agricultural Economics*, **81**(5), 1028-1041.
- Carlton, Dennis, (1979) "Vertical Integration in Competitive Markets Under Uncertainty," *Journal of Industrial Economics*, **XXXVII**, 189-209.
- Clarke, R., Davies, S., Dobson, P., & Waterston, M. (2002). *Buyer Power and Competition in European Food Retailing*. Cheltenham, UK: Edward Elgar.
- Coase, R. (1937). "The Nature of the Firm." *Economica*, **4**(November), 386-405.
- Garvey, Gerald. 1995. "Why Reputation Favors Joint Ventures over Vertical and Horizontal Integration: A Simple Model," *Journal of Economic Behavior and Organization* 28: 387-97.
- Grossman, Sanford and Oliver Hart (1986). "The Costs and Benefits of Ownership: A theory of Lateral and Vertical Integration," *Journal of Political Economy*, **94**: 691-719.

- Halonen, Maija. 2001. "Reputation and Allocation of Ownership." *The Economic Journal* 112: 539-58.
- Hart, Oliver and John Moore (1990) "Property Rights and the Nature of the Firm." *Journal of Political Economy*, **98**: 1119 – 1158.
- Hennessy, D. A. (1996)."Information Assymetry as a Reason for Food Industry Vertical Integration." *American Journal of Agricultural Economics*, **78**(November), 1034-1043.
- Jensen, H.R., Kehrberg, E.W., and Thomas, D.W. (1962) "Integration as an Adjustment to Risk an Uncertainty." *Southern Economic Journal*, **28**(April), 378-84.
- Klein, Benjamin, Crawford Robert G. and Alchian, Armen A. (1978). "Vertical Integration, Appropriable Rents, and the Competitive contracting Process." *Journal of Law and Economics*, **21**: 297-326.
- Klein, Benjamin and Keith Leffler (1981). " The Role of Market Forces in Assuring Contractual Performance." *Journal of Political Economy*, **89**:615-641.
- Kumbhakar, S.C. and R. Tveterås (2003). "Production Risk, Risk Preference and Firm-Heterogeneity", forthcoming, *Scandinavian Journal of Economics*, Vol. **105**, No. 2.
- MacLeod, Bentley and James Malcomson. 1989. "Implicit contracts, Incentive Compatibility, and Involuntary Unemployment." *Econometrica* 57: 447-80
- Murray, A. D., & Fofana, A. (2002)."The Changing Nature of Fish Retailing." *Marine Resource Economics*, **17**, 335-339.
- Paul, C. J. M. (2001a)."Cost Economies and Market Power: The Case of the U.S. Meatpacking Industry." *Review of Economics and Statistics*, **83**, 531-540.
- Paul, C. J. M. (2001b)."Market and Cost Structure in the US Beef Packing Industry: A Plant-Level Analysis." *American Journal of Agricultural Economics*, **83**, 64-76.
- Richardson, C. (2002) "Carrefour Waiting for Farmed Cod." *Intrafish*, April 2002, p. 7.
- Rogers, R. T. (2001)."Structural Change in U.S. Food Manufacturing 1958-1997." *Agribusiness*, **17**(1), 3-32.
- Spulber, D. F. (1999). *Market Microstructure: Intermediaries and the Theory of the Firm*. Cambridge, UK: Cambridge University Press.
- Tveteras, R. (1999) "Production Risk and Productivity Growth: Some Findings for Norwegian Salmon Aquaculture", *Journal of Productivity Analysis*, vol. **12**(2), pp. 161-179.
- Tveteras, R. (2000), "Flexible panel data models for risky production technologies with an application to salmon aquaculture", *Econometric Reviews*, **19** (3), pp. 367-389.

- Tveterås R. Og G. Dybvig (2003), "Firm organization in Norwegian salmon farming: A survey" (In Norwegian: "Selskapsorganisering i norsk lakseoppdrett: Resultater fra en spørreundersøkelse"), Working Paper No. 72/03, Samfunns- og næringslivsforskning.
- Tveteras, R and A. Heshmati (2002), "Patterns of Productivity Growth in the Norwegian Salmon Farming Industry", *International Review of Economics and Business*. Vol. **IL** (3), 367-393.
- Tveteras, S., Peña, J., Tveteras, R. and Bjorndal, T. (2004). "Firm concentration and vertical integration in salmon farming: Empirical evidence from Chile and Norway". Proceedings from *XVIIth EAFE Annual Conference*, Rome, 5.-7. April, 2004.
- Ward, C.E. (1993) "Comparative Analysis of Cattle Slaughter and Fabrication Costs." *Agribusiness*, **9**(September), 441-451.
- Williamson, Oliver, (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*, New York, NY: Free Press
- Williamson, Oliver E. (1985). *The Economic Institutions of Capitalism*. New York: The Free Press.