Do fluctuations in input impact industry structure?

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Abstract in Norwegian:
Denne artikkelen retter oppmerksomheten mot om, og hvordan usikkerhet knyttet til en råvare påvirker industristrukturen blant de bedriftene som levere av å bearbeide råvaren. Produksjon av tre ulike råvarer i norsk matvaresektor studeres; melk, oppdrettslaks og villfanget torsk. Ulike dimensjoner ved industristruktur som grad offentlig engasjement, transaksjonskostnader, konsentrasjon og bedriftsmangfold, studeres.

De empiriske funnene som rapporteres bekrefter på mange områder de forventningene som teoretiske modeller gir. Samtidig er noen resultater mer overraskende. Implikasjonene av funnene, både næringsmessige og teoretiske, drøftes i slutten av artikkelen.

Abstract in English:
This paper addresses whether and how variations in input may impact industry structure. Three Norwegian industries producing fresh food from different biological sources are analysed. The products under scrutiny are milk, farmed salmon and wild caught cod. The industries are compared in terms of input variations, public involvement, transaction costs, concentration and degree of firm heterogeneity.

The empirical findings reported both confirm and contradict predictions from theory, which are explained and discussed. Implications are highlighted.

Key words: Input uncertainty, transaction costs, firm heterogeneity and concentration rate

Introduction

The structure of the industry in which a firm operates is believed to be of key importance for its choice of strategy and profit potential. Porter (1980, p.3) claims that the *"industry structure has a strong influence in determining the competitive rules of the game as well as the strategies potentially available to the firm"*. However, industry structure not only varies across industries, but also over time. A variety of factors may impact industries and their structures. For example, man-made technological breakthroughs can cause dramatic industry structure changes or even give rise to new industries (see e.g. Tushman & Anderson, 1986). Also, industry structure is affected by changes in adjacent stages in the value system/chain and the bargaining power of suppliers and customers. Firms' actions and pursued strategies may as well influence the structure and thus the profit potential and competitive position for actors operating in the industry. Other important factors are scale and scope economies, capital requirements needed to operate in the actual industry, prevailing ideologies and governmental policies. Hence, factors that may impact industries and their structure are multiple. For a comprehensive overview of such factors see Porter (1980) and Besanko *et al.* (2004).

In this paper we ask whether unpredictable fluctuations in supply may also impact industry structure. This question is impor-

tant – at least due to the following two reasons: First, even though fluctuations, which relate to uncertainty, have extensively been dealt with in a variety of disciplines – such as economics, strategy and organisation science – fluctuations – or uncertainty – have to the best of our knowledge only to a limited extent been related to industry structure. For example, in Porter's (1980) extensive discussion of industry structure, this factor is not mentioned at all and in standard industrial organisation textbooks such considerations are also neglected (see e.g. Sheperd, 1997). Further, in order to operate effectively, adequate and timely supply of inputs is needed. In very much of strategy and marketing literature, adequate and timely supply is implicitly seen as unproblematic – and hardly dealt with at all. Challenges related to supply are instead left to sub-disciplines such as logistics and supply management (Ottesen & Grønhaug, 2002). In some industries, such as the fish processing industry, central input factors are nature-based raw materials where the control potential over supply is highly limited.

The remaining part of this paper proceeds as follows. In the next section we first define and clarify the central concepts to be applied. We do so to better grasp and cope with the research problem under scrutiny. Our effort to define and clarify central concepts – in particular our dependent variable "industry structure" – is theory-based, drawing on elements from economics in general, and especially from the field of industrial organisation. As part of our attempt to describe and predict whether and how uncertainty may impact industry structure, we develop a set of interrelated theory-based hypotheses where also transaction cost economics principles are utilised.

To examine our research problem empirically we collected detailed data to adequately describe and contrast three industries, all producing fresh food. The central inputs in the three industries are milk, farmed salmon and wild caught cod respectively. The three industries were selected due to varying degree of fluctuations related to – or uncertainty enveloping –the central biological input applied. To reduce the potential impact of other influencing factors, the three industries were selected as similar as possible, i.e. they all produce fresh food, production is in all three cases based on biological raw material sources, and they are all situated beneath the umbrella of the Norwegian superior legislative and political framework.

Based on detailed mapping of the three industries we report our findings, which take form of presenting the characteristics of the three industries along derived dimensions related to input uncertainty and political involvement. We then continue by reporting our empirical findings related to the hypotheses proposed. Our conclusions partly challenge and complement existing theories on how input uncertainty affects industry structure. Alternative explanations are proposed for unexpected (deviating) observations. At last we draw and discuss implications.

Central concepts and hypotheses

This section starts by defining and clarifying the central concepts we apply to grasp and cope with the stated research problem. We do so because how concepts are defined impact what aspects of, and thus how, the actual problem is captured. After this we advance a set of interrelated hypotheses on how our independent variable, input fluctuations – or maybe more precisely – input uncertainty might impact on our dependent variable, i.e. industry structure.

Basic concepts

The concepts "industry" and "industry structure" are related. However, the concepts are often applied differently – and frequently left undefined. The notion of an industry, for example, often refers to prod-

ucts (e.g. the seafood industry), countries, or central inputs and technologies applied. A more useful definition to capture the importance for competition and strategy is probably the following: *"…the group of firms producing products that are close substitutes for each other"* (Porter, 1980, p. 5). To what extent products substitutes each other relates to the inter-competition between them and can numerically be captured by measuring their cross-price elasticises of demand.

"Industry structure" relates to central aspects or characteristics of an industry. What aspects to emphasise, depend on purpose. For example, the often applied characteristic "concentration", e.g. as captured by the aggregate market share of the largest firms, is often used to indicate the intensity of competition in the industry. In this research we are – in particular – preoccupied with whether and how uncertainty may influence and restrict actors and their coping – and how this may be reflected in the way they organise their activities. Thus, we address characteristic of particular relevance for this purpose. For example, in addition to traditional measures, such as numbers of sellers and buyers, and concentration, input fluctuations or uncertainty may impact the possibilities of standardisation, investment risks, and thus the ability to pursue economies of scale.

Further, if fluctuations relate to variability in type and quality of input, this may influence the possibility for exploitation of economies of scope. Input uncertainty may also impact the potential inclusion of subsequent activities in the value system, or the acquisition of upstream units, hence, the degree of vertical integration. An important question is also whether uncertainty impacts how firms perform their transactions, including activities to secure inputs and exchange their outputs. Transactions are contract-based. An important question is whether input uncertainty impacts ability for monitoring inputs prior to purchase –a prerequisite in order to design contracts effectively.

As stated above our independent variable is input uncertainty. The concept of uncertainty has been applied in various ways. According to Knight's (1921) classical definition, uncertainty is present when actors can not assign well-defined probabilities to possible outcomes. If they can, it is the case of risk. The importance of uncertainty is underlined by Coase (1937, p. 338) who find it *"…improbable that a firm would emerge without the existence of uncertainty,"* since short-term contracts are unsatisfactory under these circumstances.

The research literature distinguishes between different sources or types of uncertainty, e.g. between primary, secondary, and behavioural uncertainty (Williamson, 1989) or primary, competitive or supplier uncertainty (Sutcliffe & Zaheer, 1998). The type of uncertainty under scrutiny here – given the biological production processes in question – is primary uncertainty – i.e. uncertainty related to state of nature. Primary uncertainty stems from random events of nature, unpredictable changes, change in consumer preferences, and regulatory- or technological changes that are difficult to predict. In this paper we distinguish between input uncertainty related both to quality and volume of supply.

Before we develop our hypotheses we briefly discuss how public involvement may moderate the impact of uncertainty on industry structure.

The moderating influence of public involvement

Firms and industries do not operate in a political vacuum. Review of the literature on industry structure reveals that public involvement may heavily moderate the structure and development of industries in several ways (Viscusi *et al*., 2005). Public authorities all over the world struggle to protect consumers from monopolies' opportunistic actions. Antitrust legislation, aiming at hindering firms from harmfully exercising a dominating market position, is now implemented in most western countries. At the

same time, public authorities implement protective measures (like tariffs and import quotas) to shield domestic industries from global competition. Well positioned nations argue for free trade, while nations in weak competitive positions argue for arrangements aiming to protect domestic industry. It should also be noted that WTO struggles to create a global set of rules for international food trade – in which two of the three industries in our study are participating.

Public involvement also includes market intervention pursuing multiple domestic policy goals, such as levelling income among primary producers, improving consumers' welfare, supporting a sustainable rural population, and multifunctional farming. These objectives are especially pertinent among the food producing sectors which often are linked with non-industrial public policy goals. Various means are applied in this effort, such as regulating terms of trade by exclusive dealerships and rules of negotiations, directing producer subsidies, laws that guarantee or restrict market competition, income schemes, barriers of international trade and price guarantees. Also, public involvement can have both intended and unintended effects on contractual relationships and industrial structure.

Here, public involvement is understood as institutionalisation of markets (Guseva & Rona-Tas, 2001) or direct intervention in some favoured industrial sectors – either by subsidisation or protective measures. In terms of contractual relations, institutionalisation is interesting in two respects. First, institutionalisation may influence industrial structure. For example, public intervention could imply sustaining a heterogeneous structure in one industry, while imposing a homogenous structure in others. Secondly, institutionalisation may also act as a risk absorbing mechanism, since economic actors can be protected from the "court of the market" in terms of for example price guarantees or mandatory contract schemes. Similar to hierarchy, institutionalisation reduces uncertainty and transaction costs. The effects should, however, be regarded as highly dependant upon sector specific goals that may vary over time and across industries.

Influencing factors and tentative hypotheses

In this section we address factors that may influence industry structure, why they do so, and how. Regarding the factors addressed we also advance – based on theory – a set of interrelated hypotheses. The conceptual and theoretical bases of the hypotheses are: transaction cost economics, vertical integration, economies of scale and scope and concentration ratio, as well as the moderating role of governmental interventions.

Uncertainty and transaction costs economics

Transaction costs are the costs associated with searching for exchange partners, negotiating, monitoring and enforcing contractual arrangements. When the transaction environment is characterised by high uncertainty, transaction costs, *ceteris paribus*, tend to increase. Transaction cost economics (TCE) – with central proponents such as Coase (1937) and Williamson (1975; 1985) – has demonstrated to be useful to explain under which organisational forms exchanges between transaction partners – in adjacent stages in the value system – should take place (Shelanski & Klein, 1995; Vannoni, 2002). In some cases the market interface is replaced by common ownership, i.e. vertical integration, which – if adapted to a large degree – has great bearing on industry structure. TCE maintains the actual transaction as the unit of analysis, and is not preoccupied with industry structure as such. However, the cumulative effect of individual firm behaviour will of course affect industry settings on an aggregate level.

Asset specificity is the main factor of importance for choice of governance structure within TCE (Williamson, 1986), and can be

defined as the tailoring of resources for specific needs. When assets are committed to specific tasks, redeployment to alternative usages implies surrendering large amounts of their productive value. The investments undertaken by transaction partners in advance of an exchange determine the level of asset specificity, which can take many dimensions. Examples can be site specificity (location), physical (machinery) and human (training, experience) asset specificity as well as temporal asset specificity which can be substantial when the exchange involves highly perishable food products. Under the presence of high asset specificity uncertainty becomes a significant determinant for vertical integration (Sutcliffe & Zaheer, 1998) due to the possibility for hold-up and quasi rent extraction (Klein *et al.*, 1978). Vertical integration then becomes a viable option to protect firms from unforeseen contingencies or contract partners' opportunistic behaviour.

Uncertainty can further serve as a barrier for potential entrants if they do not possess the market and industry knowledge of industry incumbents (Sheperd, 1997). When industry members integrate vertically, foreclosure of input sources or product outlets might be result and potential entrants confronts higher uncertainty levels. For the incumbents, however, the integration of adjacent stages within the firm boarders, alleviate uncertain contingencies, and – as accentuated by Davies (1987, p. 95) *"…the desire to avoid or ameliorate uncertainty lies at the heart of many motives for integration."* Uncertainty related to upstream product quality (Silver, 1984), input price (Arrow, 1975) and final demand (Carlton, 1979) are some sources of uncertainty that may motivate vertical integration.

The quality of an input may from nature be uncertain. If monitoring is costly – or only possible *ex-post* – upstream integration and self production may be preferred to check the quality closer. Arrow (1975) addresses information asymmetry and argues that when the input supply is uncertain, integrating backwards can improve downstream firms' ability to forecast the input price and thereby make a better input-mix decision.

Carlton (1979) addresses uncertainty in downstream demand and claims that when it appears in situations with upstream supply rigidities, backwards vertical integration can reduce costs. This follows from the assumption that upstream producers must make their own pricing decisions before downstream demand and the derived demand for their product is known. When confronted with the risk of having unsold stocks, input prices are set above marginal production costs. Then, if the downstream producer integrates upstream, inputs can be obtained at cost. However, the risk is transferred downstream. The downstream producer can produce at a relatively low level where "…*the integrated firm is able to satisfy the high probability demand by itself, and pass on the low probability demand to some other firm*." (Carlton,1979, p. 207). Hence, vertical integration can reduce uncertainties in the firm's marketplaces regarding future price movements, supply reliability or access. Thus, according to literature we predict transaction costs to rise as uncertainty related to input rises and hypothesis:

> *H_1: High degree of input uncertainty imposes high transaction costs and hierarchical contract relations*

However, when authorities intervene in upstream markets, for instance by setting the terms of trade or by assigning legislative rights to some of the contractual partners, the distribution of bargaining power between stages might be disturbed and input uncertainties resolved. Hence, high degree of public involvement in some industries can reduce transaction costs.

Uncertainty and economies of scale and scope

Economies of scale are realised from operational efficiencies, where the unit cost falls with increased production. Scale

economies are the natural cause of monopolies when the market size is within the range of the cost effective scale of one firm. The degree of specialisation, division of labour, technological and/or financial reasons (supply quantity discount) are the reasons for the falling part of the long run average cost (LAC) function, which in turn is responsible for economies of scale. Management limitations and "diseconomies of scale" are the reasons for the upward sloping part of the LAC-curve from some output volume.

When firms become more capital intensive they tend to increase in size, since high fixed costs (specialised production technology) should be spread over larger volumes of output to reduce average costs. Technological progress encourages specialisation and substitution of capital for labour – therefore larger firms. When production is labour-intensive and fixed costs are low, firms need not be penalised for being small.

Stigler (1951) explains the degree of vertical integration in an industry by its age, since specialisation increases as markets expand and specialisation leads to efficiency since more is produced per unit of input. He argues that the size of the downstream market will influence the level of vertical integration in an industry, which will decrease as markets expand and industries mature. In young industries firms will be more apt to integrate upstream since raw material providers tend to be unable to satisfy the producer's demand when downstream markets grow rapidly. As an industry matures, upstream firms tend efficiently to supply the downstream industry. Also, as specialisation increase, input markets become reliable and vertical integration declines. As the focal industry grows old and declines, upstream market might diminish and vertical integration might again become necessary to secure the inputs needed.

Harrigan (1984) opposes this view, and posits that firm's level of vertical integration over the life-span will take an inverted U-shape, since less vertical integration should be favoured early and late in the industry's evolution due to the risks of demand uncertainty and differing needs to prove a new product's worth. These factors call for lower level of integration since the market penalty from misalignment will be great. However, she makes one exception – for pioneering firms – and asserts that technological leaders in an industry will be more integrated than their followers. The arguments of Stigler and Harrigan are adverse in the meaning that while Harrigan addresses vertical integration as a firm level phenomenon, Stigler's point of view is that from the industry level. Accordingly, their dispute seems to belong to the traditional debate on whether performance effects stem from firm or industry factors as addressed by Hawawini *et al.*, 2003.

Vertical integration should induce a downward shift in the firm's LAC curve, and increase economic efficiency. Then cost benefits can be achieved by production economies (e.g. reduced transport costs), co-ordination economies (e.g. reduced transaction or advertising costs), managerial economies (e.g. single supervision source) or financial economies (e.g. quantity discounts, reduced interest costs).

Input uncertainty may impede the realisation of scale economies. The utilisation of input specific production equipment – that can bring about (further) operational efficiencies – assumes that inputs are of homogeneous kind and supplied in sufficient quantities. Scope economies follow from the advantages from producing several outputs (from the same input) together, rather than by separate firms, and are decisive for the firm's product mix. The diversification of outputs (scope) influence on costs is measured by cost savings due to simultaneous relative to separate production. However, the occurrence of multi-output production within a single multi-product firm instead of separate single product firms requires that it is difficult to trade common inputs across markets, i.e. transaction costs are present (Teece,

1982). If not, the diversification incentives disappear. Teece claims that when transaction costs prevents efficient market exchanges the profit maximising firm will choose multi-product diversification. Levy & Haber (1986) also show convincingly how multi-product firms benefit from flexibility due to the ability to shift inputs and/or organisational assets to other, "higher value" usages when demand uncertainty is present.

In the view of Porter (1996, p. 70) strategy is making trade-offs which also includes deciding what *not* to do. Flexibility then, as an argument related to scope economies, becomes a response to environmental uncertainty (Tannous & Mangiameli, 1993; Olhager & Rudberg, 2003) since firms' ability to change to variations in the business environment becomes valuable. Baumol (1959) also asserts that uncertainty will lead firms to under-invest in specific equipment. This implies that use of production facilities, whose scale of operation is flexible, will increase. Hill & Hoskisson (1987) further claim that environmental uncertainty places a premium on flexibility, where vertical integration might induce inflexibility and poor responsiveness. Based on the above discussion we hypothesise that:

H_{2A}: High degree of input uncertainty favour economies of scope

H_{2B}: and correlates positively with firm heterogeneity

However, public involvement may impact actors and industry structure. Authorities, in their quest for consumer benefits, usually limit large firms' access to monopolistic pricing behaviour. Hence, in industries where public involvement is high, concentration ratios tend to be reduced. Also food safety issues and legislative measures related to them might hinder firms from efficiently utilise economies of scope and thus foster firm homogeneity.

Uncertainty and firm concentration ratio

Industries differ with respect to degree of concentration. Due to factors such as entry barriers and scale economies, high capital requirement is often the case, which can also result in high sunk costs: constituting a considerable *exit* barrier if production technologies are highly specialised and where production equipment and facilities receive low salvage value. Location, input distributor scarcity, and legal reasons can as well influence entry barriers. Governmental authorities can also to some extent influence the concentration ratio in an industry for instance by antitrust laws or by the attitude and behaviour towards the 'openness' of the economy.

Antitrust laws may also limit the extent of horizontal and vertical integration, while the international linkages of an industry affect the market size, and hence, the room for action. Concentration effects can also be achieved by vertical integration, especially if it enables the acquiring firm to foreclose competitors from the upstream market. However, when supply is characterised by primary uncertainty, firm's ability to obtain scale – or other – economies from vertical integration, is limited. Uncertainty surrounding the inputs will function in the same ways as when raw material sources are scarce and no one have obtained specific control over these. Then, actors will be reluctant to undertake specific investments needed for efficient production scales, since supply volumes might be insufficient to provide effective capital utilisation. Thus we hypothesise:

H_3: High degree of input uncertainty favours low firm concentration ratio

However, industries situated under the wings of protective governments, whose purpose is to shield them from global competition, or when legislative monopoly rights are granted, industry structure is expected to be more concentrated than otherwise.

Research Method

To examine the stated hypotheses we chose to study the structure of three different industries. The industries included are all producing highly perishable fresh food and located in Norway. Fresh food is chosen because raw material quality is essential for product differentiation. Additionally, the raw material is based on biological production/harvesting which is sensitive for climate conditions and supply often takes a seasonal nature. This lead to variation in input volumes and quality. Distribution of fresh food is especially demanding, as product quality depends on a short time span between production and consumption.

To add variation to our dependent variable – input uncertainty – we chose to study three different products; milk, wild caught cod and farmed salmon. We also chose to study the industry structure in the part of the value system that processes the biological raw material. The industries chosen also allow for capturing how public involvement may impact on industry structure.

The data collected for our study is based on the need created by our hypotheses requiring information (data) about input uncertainty, public involvement, transaction costs, concentration and firm heterogeneity. To capture input uncertainty we have measured degree of input standardisation, input volume variation and input price variation.

Public involvement has been captured by degree of globalisation in both input and output markets as well as degree of national protection both related to subsidises and in terms of trade.

Transaction costs in the market interfaces have been captured by the degree of vertical integration between raw material production and processing, and terms of trade, i.e. widespread/utilisation of auctions and contracts.

Degree of heterogeneity has been captured by firm variation in term of size, product mix and degree of specialisation. We have also assessed the degree to whether competitive advantages among firms within the same industry are based on economies of scale or scope.

To capture degree of firm concentration we have measured concentration rate, together with number of buyers and number of sellers.

Findings

Below we report the findings from our investigation. To ease the presentation the variables studied are dichotomized in to dimensions like high/low or global/national. The findings are presented by comparing the relative values of the included categories (variables) in the three selected industries. The presentation of findings follows the order of hypotheses. We start by presenting our findings related to degree of input uncertainty and public involvement.

Input uncertainty and public involvement

As discussed above, it is assumed that degree of input uncertainty may impact the industry structure in several ways. It is also assumed that public involvement may moderate the way input uncertainty impact industry structure.

Table 1 shows our findings related to input uncertainty and public involvement in the three industries studied.

Inspection of Table 1 reveals that the degree of input uncertainty varies across the industries studied. In the processing industries based on agriculture and aquaculture, i.e. milk and farmed salmon, input uncertainty is low in the sourcing environment. The processing industry based on wild cod is, however, exposed to high degree of input uncertainty due to factors such as weather conditions, variations in catch rates and biological migration. Inspections

of Table 1 also show that this is the case when considering all of our exploratory variables; variation in quality (i.e. standardisation of input), volume and price variation.

Table 1 also shows that public involvement is greater in the agricultural, i.e. the dairy industry, than in the marine sector, i.e. wild caught cod and farmed salmon. In Norway, agriculture is strictly protected from global competition – including import protection from products and inputs produced abroad, subsidies aimed at increasing the profitability within the industry, as well as laws instructing the organisation of the industry and the level of prices in the input markets for agriculture products. Thus, all milk consumed in Norway is produced domestically. In the marine sector public involvement is very low – both in the farmed salmon industry and in wild caught cod industry. Apart from agriculture, the terms of trade are set by international markets. Since early 1990's there have been no subsidies directed to the marine sector. Accordingly, most of the farmed salmon and wild cod are sold and consumed abroad. As such, the three industries studied show variations both on the independent variable, i.e. input uncertainty, and the moderating variable, i.e. public involvement.

Table 1 Input uncertainty and public involvement in three Norwegian food industries

Construct	*Variable*	*Milk*	*Salmon*	*Cod*
Input uncertainty	Standardisation of input	High	High	Low
	Volume variation	Low	Low	High
	Input price variation	Low	Medium	High
Public involvement	Competition input market	Low	High	High
	Competition output market	Low	High	High
	Globalisation output market	National	Global	Global
	Globalisation input market	National	Global	Global
	National protection	High	Low	Low

Input uncertainty and transaction costs

According to our first hypothesis (H_1) the level of input uncertainty should impact transaction costs positively. In Table 2 we have summarised our findings related to transaction costs.

Inspections of Table 2 reveal that the findings are in accordance with the hypothesis. The highest transaction costs are found in the raw material market for wild caught cod, where the input uncertainty is highest.

The lowest transaction costs are found in the dairy industry, where the input uncertainty is the lowest. Transaction costs are also low in the market for farmed salmon and close to those of the dairy industry. Inspection of Table 2 indicates that transaction costs are driven by different aspects of input uncertainty. The degree of vertical integration is high in the dairy industry, where the farmers collectively own the major processing company – Tine. In spite of high degree of input standardisation of quality, market auctions are absent and monitoring unnecessary. Here long term contracts are applied to handle transactions – and minimum standards regarding the quality of the milk are employed and adhered to by farmers.

Table 2 Transaction cost in raw material markets in three Norwegian food industries

Construct	*Variable*	*Milk*	*Salmon*	*Cod*
Transaction costs	Degree of vertical integration	High	Low	Low
	Number of auctions on input	Never	Low	High
	Contracts on input	Often	Often	Seldom
	Terms of contract	Long	Short	Short
	Inspection of input before purchase	Never	Seldom	Often

Within the farmed salmon industry transaction costs are slightly higher than in the dairy industry. The degree of vertical integration at the industry level is low and most of the farmed salmon are sold to processors abroad. However, at the firm level high degree of vertical integration is partly present. Those who process farmed salmon in Norway are in general backward integrated (Isaksen *et al*, 2002, Isaksen, 2007). Farmed salmon is most frequently mediated through short term contracts or auctions. Prices are set globally and fluctuate to a higher degree than the prices for raw milk (see Table 1). Due to small quality variations, inspecting the salmon before purchases are mainly unnecessary, hence, buyer ex post monitoring costs and risks are reduced. The duration of contracts is usually on shorter terms than for milk. In the later years, commodity exchanges for salmon have emerged and functioning as financial security instruments for salmon exporters.

The industry with the highest transaction costs in our study is the wild caught cod industry. The shown variations in transaction costs reflect different aspects of input uncertainty. Due to high quality variation almost every catch need to be inspected before purchases are made. The catch is often landed directly to the buyer. Most of the catch is sold on a day-to-day basis, where price is decided after inspecting quality and volume of today's catch. Another factor that increases transaction costs in this market is that the catch often includes other species than cod. Due to input uncertainty, long term contracts are hardly ever applied. An often proposed strategy in such markets to reduce transaction costs is upstream vertical integration. Surprisingly, when comparing the three industries, we find this strategy most seldom applied in the wild caught cod industry. This may, at least partly, be explained by public involvement, since processors – according to law – are not allowed to own and operate fishing vessels. The policy goal was to establish a secure privilege for Norwegian fishermen to harvest the wild fish resources. However, some exceptions from this law have been made, where processors have been granted the right to own vessels, and the vessels must sell their catch to one specific processor or region. Several studies indicate, however, that upstream vertical integration only marginally reduces the input uncertainty in this market (Dreyer *et al.*, 2001; Isaksen *et al.*, 2002; 2004; Isaksen, 2007). The major explanation for these findings is that the way the value system is organised neither impact on climate conditions nor the way the cod migrates, and this input uncertainty remains almost the same regardless ownership in vessels.

Our findings related to public involvement are mixed. As indicated in Table 1, public involvement is the strongest in the dairy industry and lowest in the farmed salmon industry. Inspection of Table 2 reveals that transaction costs are low both in the dairy industry and salmon industry. Although the public involvement is lowest in the farmed salmon industry, the transaction costs are higher in the wild caught cod industry. Here the transaction costs are related to primary uncertainty – not under control by man – i.e. biological migration and climate, which

only marginally is moderated by public involvement. In sum our observations indicate that input uncertainty impact positively on transaction costs.

Input uncertainty and scale economies

According to our stated hypothesis, input uncertainty impact on firms' ability to exploit economies of scale. We also proposed that when firms are well positioned for economies of scale, input uncertainty will impact negatively on profiting from them, while if positioned for economies of scope, the effects are indecisive or even positive. Thus, we suggest that when exposed to input uncertainty, the industry structure will develop in the direction of firm heterogeneity and product flexibility in order to respond coherently. In Table 3 we summarise our findings regarding firm heterogeneity.

Table 3 Firm heterogeneity in three Norwegian food industries

Construct	*Variable*	*Milk*	*Salmon*	*Cod*
Degree of firm heterogeneity	Firm size heterogeneity	Low	High	High
	Quality based product heterogeneity	Low	Low	High
	Product differentiation	High	Low	High
	Type of economies realisation	Scale	Scale	Scope
	Degree of specialisation	High	High	Low

A closer inspection of Table 3 shows that firm heterogeneity, i.e. size, technology, and product mix differences, are highest in the farmed salmon industry and wild caught cod industry. In particular, we find extreme heterogeneity in the wild cod industry. Looking closer at the variables related to product mix, we see that in the wild caught cod industry the mix of products is directly linked to the fluctuations in input quality. Here we also observe that firms are low in degree of specialisation and high in degree of product flexibility. Inspection of Table 3 also reveals that the well performing firms in the wild cod industry exploit economies of scope rather than economies of scale (Dreyer & Grønhaug, 2004; Dreyer, 2006, Isaksen, 2007).

In the farmed salmon industry, where input uncertainty is lower than in the wild caught cod industry, highly specialised firms tend to exploit economies of scale producing one standardised product. However, in this industry high firm heterogeneity is present in terms of variation in firm size, and also the way the value system is organised. Some firms are vertically integrated, some located abroad, and some have specialised in producing one single product. These choices relate to technology, product and capacity and are based on standardised inputs and specialisation.

The industry with the least heterogeneity is the dairy industry. Here, firms are more or less similar regarding size, technology and product mix. Firms are highly specialised and focus on economies of scale and exploitation of production capacity. When it comes to product portfolios, the dairy industry differs from farmed salmon. Here we find a wider product mix, based on milk as a standardised input combined with other inputs. The product differentiation is, however, not based on variation in input quality of raw milk, but on its application for further processing, aiming to serve various industrial customers' needs.

When it comes to public involvement, the impact on firm heterogeneity is largest in the dairy industry, focusing on an institutional framework aimed at homogeneity and exclusion of foreign competitors.

Table 4 Firm concentration rate in three Norwegian food industries

Construct	*Variable*	*Milk*	*Salmon*	*Cod*
Degree of Concentration	Concentration rate	High	Low	Low
	Number of buyers	Few	Many	Many
	Number of sellers	Many	Many	Many

Input uncertainty and concentration

In the literature degree of concentration is frequently mentioned as one of the most important dimensions related to industry structure. This is a relatively uncomplicated dimension to measure. It is also an important dimension in many theoretical models, in particular in economics and strategic management. Here we focus on how input uncertainty may impact on concentration ratio.

Our hypothesis (H_3) predicts a negative relationship between input uncertainty and firm concentration ratio. Inspection of Table 4.4 indicates support for this hypothesis. Although multiple sellers are present in all the industries studied, the industry with the highest concentration is also the one with the least input uncertainty – the dairy industry. Here we find one dominating buyer owned by the farmers. In the marine sector, i.e. firms processing farmed salmon or wild caught cod, we find low concentration ratios. We also observe that there is one way the two marine industries differ regarding degree of concentration: the farmed salmon is to a higher degree processed by firms located abroad, as farmed fish is exported unprocessed and processed in the import country. This might be explained by lower input uncertainty and lower transaction costs, resulting in a higher degree of global sourcing of farmed salmon than is the case for wild caught cod.

Again public involvement seemingly impact concentration. In the dairy industry national laws prohibit import of raw milk and milk products which contribute to a higher degree of concentration. Additionally, although firm concentration ratios are extremely high, the institutional framework in the Norwegian dairy industry contributes to, rather than prevents, high concentration rates. We believe that producers located abroad would choose to purchase their raw milk form other than Norwegian farmers if public intervention like subsidises and import protections were repealed. Thus, in an open global market degree of concentration among processors serving Norwegian consumers with milk would probably have been less. The impact on economies of scale can also lead to an opposite outcome, where the Norwegian dairy industry is merged with foreign dairy firms, like in the existing Nordic dairy firms. However, the agriculture sector in Norway has high political legitimacy open for political and regulatory intervention.

Such protective institutional tools are, however, absent in the marine sector. This sector has low public involvement and operates in an open global market and is vulnerable to protective intervention in global trade because the volumes produced are much higher than domestic consumption. In this industry public involvement is related to restriction on who is allowed to harvest how much from wild fish stocks and areas opened for farming salmon.

Concluding remarks

This study addresses how and why input uncertainty may impact industry structure. Our findings show that input uncertainty impact positively on transaction costs and firm heterogeneity. Concentration ratios, however, tends to decrease as input uncertainty increase. Additionally, our study addresses how public involvement moderates the impact of input uncertainty on industry structure. Our findings also reveal that pub-

lic involvement has an important moderating impact on industry structure. In the industries studied it was found that public involvement reduces transaction costs and firm heterogeneity, but increase concentration ratios. However, public involvement is rooted in political goals that differ from industry to industry. In this study, for instance, public involvement aiming to protect national industry from global competition, have major impact in the dairy industry. Such protective tools, however, represent a major challenge for the Norwegian seafood processing industry, if importing countries apply the same kind of protection for their own food industry.

The findings reported here have theoretical implications. According to our study input uncertainty has a potential impact on industry structure through transaction costs, firm heterogeneity and concentration rates. As noted above, this has more or less been neglected in past research. Further empirical and conceptual studies are needed in order to improve the way theoretical models should incorporate input uncertainty. Another challenge, related to a better understanding of how industry structures develop, is to study the impact of public involvement. For instance, in order to protect an industry with high political standing from global competition, tools that increase concentration ratios and restrain firm heterogeneity are utilized by authorities. On the other hand, such interventions reduce transaction costs. Public involvement is often mentioned as a factor that impact on industry structure. Our findings confirm this. However, more studies are needed in order to better understand the intended and unintended moderating impact from public involvement to include this variable into theoretical apparatus.

The reported findings also have some managerial implications. Input uncertainty affect strategy positioning at firm level. For instance, high input uncertainty seems to assign competitive advantages to firms possessing flexibility to volume and product mix. Accordingly, firms that can take advantage of standardised inputs are in a position to exploit economies of scale and specialisation strategies.

Our findings also reveal some major challenges in the three industries studied. In the Norwegian dairy industry the firm(s) is (are) vulnerable for changes in public involvement that opens for global competition. Although exploiting economies of scale today, this is hardly enough if foreign competitors were enabled to enter the Norwegian market. If so, a strategy recommended would be product differentiation rooted in input quality. However, this is not an easily adoptable strategy, since – for decades – the main strategy has been to improve and standardise input quality. This is an experience also recognised by new national actors who have tried to enter this market.

The industry experiencing the highest input uncertainty faces other challenges. In the fish processing industry utilising wild caught cod input uncertainty hassles firms. The uncertainty related to inputs, however, has created competitive advantages for those providing products based on unique input quality or having found profitable market niches. If input uncertainty is reduced, for instance through increased volumes of farmed cod, the possibility to exploit these kinds of competitive advantages will be reduced and open for radical changes in the industry utilising wild caught cod.

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