Magic Pelagic – The Creation and Distribution of Value in Networks: Experiments Conducted in a Multi Agent-Based Simulations Model of the North Atlantic Herring Network

Atle Følgesvold[a,*] and Frans Prenkert[b]

[a] Department of Marketing, BI Norwegian School of Management, Oslo, Norway
[b] Department of Innovation and Economic Organization, BI Norwegian School of Management, Oslo, Norway

Competitive paper prepared for the 23rd Annual Industrial Marketing and Purchasing (IMP) Conference, Manchester, UK, August 30th – September 1st, 2007.

* Corresponding author. A. Følgesvold: atle.folgesvold@bi.no

Magic Pelagic – The Creation and Distribution of Value in Networks: Experiments Conducted in a Multi Agent-Based Simulations Model of the North Atlantic Herring Network

Abstract

The industrial network connecting herring supply with demand comprises two separate but related sub-networks, identifiable based on the origin of the herring as coming from either Norwegian or Icelandic catchers. The sub-networks are distinct in that they show two different ways of organizing the exchange system between the levels of catch, primary processing and export of herring, while they both supply many of the same customers. This study models such an industrial network as an exchange system using a multi-agent simulation to perform experiments testing how variations in uncertainty regarding the characteristics of the input resource in combination with changing demand patterns of users affects the accumulation of exchange values in the system as a whole and the distribution of value between the two sub-systems. Although inconclusive, results indicate that the internal organization of the sub-networks matters in relation to the realization and distribution of value among its members and between the two structures. Some types of organization are more adaptive to some changes in conditions and are better suited to absorb such changes compared to other types of organization.

1 Introduction

Norwegian winter herring, or *Norsk Vårgytende Sild – NVG*, in Norwegian, is a special kind of herring, which is being caught and processed for human consumption. The activities involving catching, processing, distribution and retailing of herring are parts of a large industrial network comprising many actors with different roles in the transformation process of the herring. Such networks can be seen as complex exchange systems (Prenkert & Hallén, 2006) in which resources are being transformed from natural conglomerate resources into assortments ready for human consumption by end users (Alderson, 1957, 1965; Alderson & Martin, 1965). These exchange systems – or industrial networks – are conducive to the matching of production structures with patterns as consumption, hence performing one of the basic tasks of marketing (McInnes, 1964; Shaw, 1912).

The industrial network connecting herring supply with demand (termed the 'herring network' here) comprises two separate but related sub-networks, identifiable based on the origin of the herring. Herring caught and fed into the system by Icelandic vessels through Icelandic primary processors constitutes the basis for the Icelandic sub-network, whereas herring caught and fed into the system by Norwegian vessels through Norwegian primary processors constitutes the basis for the Norwegian sub-network. These sub-networks are distinct in that they show two different ways of organizing the exchange system between the levels of catch, primary processing and export of herring. However, they both supply many of the same customers and eventually provide European and in part Asian retail with herring based products.

The herring network thus performs the fundamental economic task of matching consumer demand patterns for herring with production structures and with the supply of that particular conglomerate resource (Alderson & Martin, 1965). The exchange system provides access to a processed version of the conglomerate resource suitable for consumption. The economics of this lies in that this transformation of a conglomerate resource into a product suitable for direct human consumption entails the creation and appropriation of *value* by the system.

2 Problem and Purpose

This paper is concerned with the concept of value, its creation and appropriation (or accumulation) in exchange systems. We base our investigation of these phenomena on the herring exchange system including the Icelandic and Norwegian sub-networks. Our basic inquiry relates to how value is created and accumulated in the system, and how the creation and accumulation of value changes depending on variation in the quality of supply of the conglomerate resource, and in the demand for quality in the final product from end users. Or more specifically; given an industrial exchange system (network) comprised of two sub-networks such as the Icelandic and the Norwegian networks – how can we understand how changes in the supplied and demanded quality of the output (processed herring) of the system affects the distribution of value between two supply-networks differing only in their internal organization?

We will present a model of quality variation and shifts in the exchange system utilizing a multi agent-based simulations model in order to generate a better understanding of the behaviour and sensitivity of the system to such changes. Such an understanding is crucial for actors within the system as well as for actors aiming at regulating the system.

The paper will continue with a discussion of the methodological choices made, thereafter a section outlining the view on value and value distribution in exchange systems will be presented. After that comes a description of the North Atlantic herring exchange system case outlining the two supply-networks and the demand side of the herring network. The following section in describe the simulations model is in some detail followed by the reporting of our experiments. The paper concludes with a discussion of our findings outlining some implications for our understanding of value accumulation and distribution in exchange systems and networks.

3 Methodological Considerations

3.1 Study Approach and Design

This paper reports an investigation into the "North Atlantic herring network" based on a qualitative approach (Morgan & Smircich, 1980) utilizing case studies to create pictures of the network and an understanding of its mechanisms (Pettigrew, 1997). The reason for using case studies was the requirement to get a rich picture and a well-developed understanding of the mechanisms controlling the functioning of the herring network conceptualized as an exchange system. Case studies are especially useful when underlying mechanisms that shapes patterning in events are under investigation (Dubois & Araujo, 2004; Pettigrew, 1997), as is the case with this study.

In developing the case studies, data and theory interacted and shaped each other in a way characteristic for case studies (Dubois & Gadde, 2002; Ragin, 1992) which contributes to tightening the study to some extent and to create a sense of direction in the enquiry (Ragin, 2000; Miles & Huberman, 1994).

3.2 Data Collection

Data were collected through semi-structured interviews with actors in the North Atlantic herring network. Icelandic as well as Norwegian catch and processing firms were included. Semi-structured interviews with customers in Poland as well as interviews with industry experts on the demand structure in Russia and Germany were also conducted to cover the demand side.

3.3 The Role of the Case in Building the Simulations Model

The mechanisms identified and uncovered in the case studies form the foundation for the construction of an agent-based simulation model of the exchange system. The simulations model is thus based on “cased” data (Ragin, 1992), and is realized as a model of an industrial network made up of the three central types of actors (catch-operators, industrial processing operators, and retailers) is constructed. This model is then transformed into an agent-based simulation (Gilbert & Troitzsch, 1999; Axelrod, 1997) a simplified, abstracted and quantified model of the empirically studied network. Series of experiments was conducted within this simulated environment in order to explore the effects over time of changes in central variables, and the boundary conditions for the emergence of significant changes in relationship formation and exchange value distribution. This paper reports results from some of these experiments.

4 Value in Exchange Systems and Networks

In this paper we focus on value and how value is generated and distributed in an exchange system or a network. Value is a concept carrying many connotations and it has been subject to many analyses from fields such as strategy (Porter, 1985; Porter & Millar, 1985), management (Fjeldstad & Ketels, 2006; Normann & Ramírez, 1993, 1994; Stabell & Fjeldstad, 1998), and marketing (Anderson, 2004; Anderson & Narus, 1998, 2004; Ravald & Grönroos, 1996). From a business relationship perspective, Blois (1999, 2003, 2004) suggests a set of value equations based on the works of Day (1999), to conceptualize the perspectives of the supplier and customer, respectively and how value is generated in exchanges. Blankenburg Holm, Eriksson, & Johanson (1999) suggest value to be analyzed and understood as a function of the adaptations made through commitments between two parties in a relationship.

All these discussions and conceptualizations of value share the common idea of the exchange as the source of value. Based on the exchange, Håkansson & Prenkert (2004) develop a conceptualization of value as stemming from two different but equally important sources; the exchange itself and the context in which the exchanged resource are being applied and embedded, in line with the idea of Johanson & Wedin (2000).

We distinguish value from utility[1], in that utility (Shaw, 1912; Weld, 1916) is seen as the *unrealised potential* inherent in resources stemming from the heterogeneity assumption (Alchian & Demsetz, 1972; Alderson, 1957, 1965; Alderson & Martin, 1965; Penrose, 1959), waiting to be realized by a process of value realization, whereas value is the *specific realized result* of ongoing interaction processes in a certain context in a certain moment in time, at a certain place by a certain entity claiming ownership to certain resources. Value is the result of such processes freeing the utility potential inherent in heterogeneous resources. This utility potential is what Edith Penrose calls the "services" that a resource can render (Penrose, 1959).

The conceptualization of value by Håkansson & Prenkert (2004) is based on a classical economic distinction suggested by Marx (1845/1967, 1964) and developed by Böhm-Bawerk (1888) and Menger (1871), viewing value as being of two kinds: *exchange value* and *use value*. Exchange value arises from the processes of two parties relating to each other in a given dyadic exchange *and* to others *simultaneously*. Use value arises from the capability of each party to *independently* contextualize the resources acquired from the exchange *independently* of the exchange in question, thus entailing a moment of *closure* of an otherwise open system (Håkansson & Prenkert, 2004). Hence, value creation comprises both processes of *relation* – in terms of relating to another party in a dyadic exchange; *mediation* – in terms of the simultaneous relation to others via a given exchange dyad; and *isolation* – in terms of choosing on a systemic closure.

Following the discussion above, we will measure exchange value as the dependent variable in our experiments as one way to model the value creation and distribution in the herring exchange system. We do not consider use value simply because from the point of view of the exchange system as a whole, the use value related to one given exchange can be seen as the exchange value in a subsequent exchange. It is a matter of two different closures within the exchange system isolating certain parts while relating to others and mediating some. Although distinct when considering any single specific exchange, the distinction between use value and

[1] In this paper, we view utility in line with the conceptualizations made by Shaw (1912) and Weld (1916) identifying four utility types: form, place, time and ownership. These utilities have been identified as central sources of value in complex exchange systems as networks (Prenkert & Hallén, 2006).

exchange value dissolves when considering an economic exchange system as a whole, because then the closure is made around the whole system. Thus, we can measure the total creation and appropriation of value in an exchange system by simply aggregating the exchange values realized in each micro exchange in dyadic interaction of the system. Hence, in our simulation, we add all the exchange values generated in all the different micro exchange dyadic interactions in the exchange system to form a measure of the *distribution of accumulated exchange value created over time between the two supply structures modelled.*

4.1 Implementing the Realization of Value in the Simulations Model

In the simulations model, the exchange value generated from the exchanges is implemented as the *difference between a certain characteristic of an exchanged resource and the expectations a user of this resource have* (Alderson, 1957, 1965; Alderson & Martin, 1965). We shall elaborate this to some extent.

Firstly in looking at the resource being offered, the characteristics of a certain exchanged resource are the services rendered by it (Penrose, 1959). This is implemented in the model as the "quality" of the resource in question and is assigned a numerical value (0-100; see also section 6.3 for more details) representing this characteristic.

Secondly, a user of this resource experiences a consequence of the acquisition of the resource in terms of how close it is to the user's *a priori* preferences for this kind of resource (Alderson & Martin, 1965). These preferences are formed as a function of the demand they are facing from end users (consumers) of the resource, and the structures(s) of other resources and activities that the traded resource will interface with in order to be transformed into different end states or assortments.

Hence, the gap between the services rendered by a certain given resource acquired in an exchange and the user's preferences set for the resource denotes the exchange value realized in the exchange (Alderson & Martin, 1965, p. 126). The closer the user can get to the set preference level in this matching, that is, the smaller the gap, the higher the value for the user and, thus the higher the realized exchange value. The same principle applies for the entity offering the resource: The better the match between the quality of their offer and the quality preference of the user, the higher the realized exchange value. The worse a match, the lower the realized exchange value. This is how we have implemented the realization and appropriation of exchange value in the simulations model (see also section 6.3).

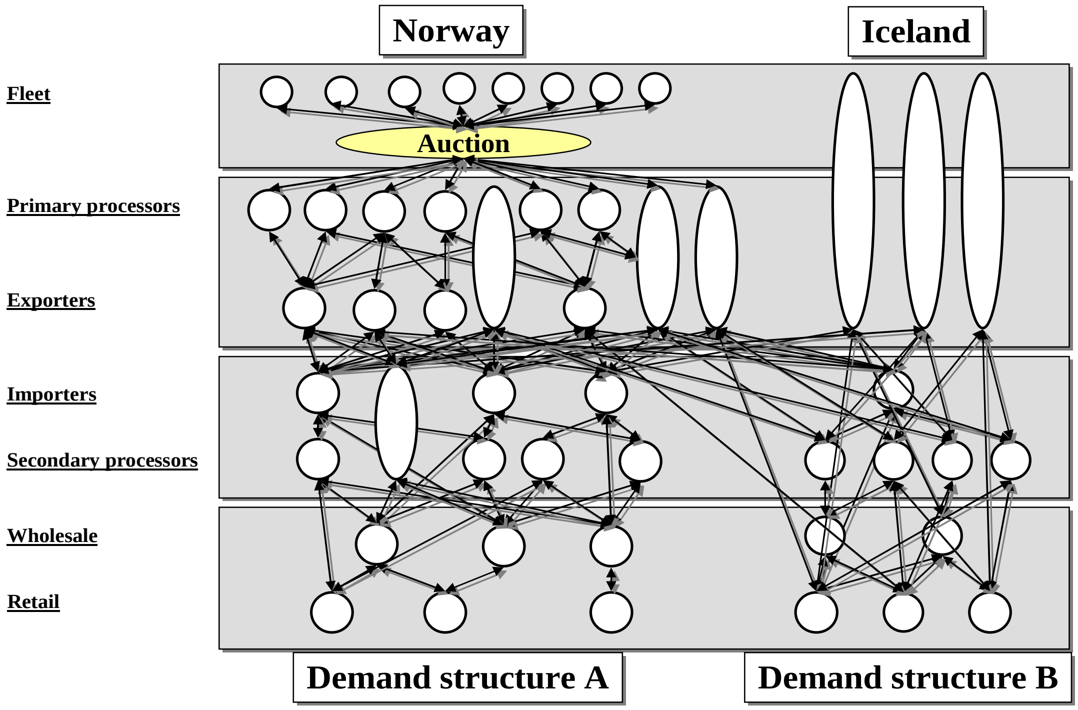

Figure 1: The Basic Structure of the North Atlantic Herring Exchange System

5 The North Atlantic Herring Network as an Exchange System

As we have touched upon earlier, we view the North Atlantic herring exchange system as comprised of sub-networks that are interlinked through a common source and common markets. The supply-side of the network is made up of the Norwegian and the Icelandic supply-networks respectively, while we have chosen to view the demand-side of the network dividable into two sections, defined by the demand put upon the supply-structures by the members of these groups (see **Figure 1**). We will deal with the demand side in more detail soon; bet let us first examine the supply-side of the cased network.

5.1 The Norwegian Supply Network

The Norwegian sub-network consists of a number of more or less independent actors purchasing, processing (gutting and filleting mainly), freezing, and marketing herring to industrial actors that are mainly located outside of Norway. The industry can be seen as comprising two main functions; primary processing and exporting. In many cases these will be one company, but there are a number of both pure processors and pure exporting firms.

The supply of herring is, not surprisingly, a key issue for the existence of this network. For the Norwegian herring sub-network, supply comes from the Norwegian (and to a lesser extent, foreign) fishing fleet. This consists of fishing vessels operating out of and landing catch in Norway. While these vessels deliver their catch directly to processing facilities along the coast, the coordination between fleet and buyers of pelagic products is controlled and handled through a central system. (See **Figure 1,** above.)

The way interaction between catch vessels and industrial actors is organized plays an important role in this study. As a function of Norwegian regulations and the way the catch side is organized, all transactions between those who catch herring and those wanting to buy have to be conducted through the central auction system. This auction is owned and operated by Sildesalgslaget, an organization with its roots going back to the first herring fisherman organization founded in 1927 in order to increase the bargaining power of the fishermen when dealing with the industry and owned and governed by the pelagic fishermen. Since 1989 Sildesalgslaget has been the sole sales organization for pelagic fish landed in Norway.

Today, they operate the largest auction for pelagic fish in Europe, with an annual turnover of about 4 to 6 billion NOK. This is from a volume of about 2 million tons of fish distributed on 15-20000 landings along the coast. Modelled on a Dutch flower auction system, the Sildesalgslaget auction is set up as a blind auction where the buyers are unaware of whom else is bidding and how much they are bidding. When logging on to the auction system, the buyers get a list of the available catches with information on volume, quality-estimates, time of catch, and distance from landing facility etc. This list is generated as fishing vessels report their catches to the auction operators, and the vessels also specify to what areas they are willing to deliver their catch when doing this. Based on this, the bidders can enter a prioritised list of bids on a set of the available catches, and they are also able to enter a minimum total quantum they are willing to accept. After the auction closes, the auction engine returns an allocation of catches to buyers[2].

[2] There have actually been occasions where the system has been unable to arrive at a workable solution, and the process has had to be restarted after manually changing some of the input to the system.

When the optimization process is completed, fishing vessels are contacted with information on bidder and location of landing for the winning bid. If the captain chooses to accept the winning bid (there may be cases where he has reservations), the buyer is contacted and informed about which, if any, catches he has won. The buyer can then start preparing for the landing and schedule production for the next hours based on what catches he knows will be coming in. The auctions close up to four times a day (depending on season), and there seems to be a general consensus among the actors in the network that this is a relatively efficient system for directing catches to buyer as they become available.

5.2 The Icelandic Supply-Network

A major shift in the Icelandic herring industry has taken place from the 2001 season on. Until the 2001 season, the bulk (more than 60%) of Icelandic catch of herring had been going to fish-meal and fish-oil production. Having observed the high prices Norwegian suppliers attained for herring going to human consumption around the turn of the millennia, Icelandic companies invested heavily in equipment enabling them to increase their suppliers to such markets before the 2001 season. The most important investments made were the contracting of several large trawlers. Compared to the purse seiners dominating until then, the trawlers are able to catch herring with a lot less damage and therefore higher quality. Combined with an increase in freezing on land this enabled Icelandic companies to increase the percentage of herring going to human consumption from less than 20% until then to more than 50% and rising from 2001 on.

In 2001, Icelandic companies started harvesting larger quantities of NVG using large trawlers. The NVG were frozen at sea and most of it was marketed to the processing industry in Poland, which happily welcomed the Icelandic suppliers as an alternative to the Norwegians (see also **Figure 1,** above). This way of operation means that the Icelandic herring for the most part never will be landed on Iceland, and that there is no need to operate processing facilities for pelagic fish going to human consumption on shore.[3]

5.3 Supply Structure Organization – Central Empirical Findings

As we have showed, the key difference between the Norwegian and Icelandic pelagic industries is how they are organized. While, as described above, the Norwegian industry can

[3] There is still a significant production of meal and oil from pelagic fish on Iceland, but that lies outside the scope of this study.

be characterized as highly fragmented and with very little vertical integration, the Icelandic industry is more or less the opposite. A small number of companies dominate the industry, and it appears to be the industrial actors that drive the development of the industry. Together with the very different organization of exchange between catch and industrial actors between the two supply structures, this has lead to a number of differences between the two structures. The most important differences for the purpose of our inquiry are connected to the ability of these structures to handle uncertainty and evolving user preferences.

The Norwegian structure is, due to the freedom of matching of the auction system, more effective in absorbing the natural variation in quality and quantity this source of raw material exhibits. This variation, which is partially stochastic in nature, is in principle more difficult to absorb for the Icelandic actors who are 'tied' to specific vessels in terms of sourcing. The Icelandic structure, on the other hand, should be better at adapting to systematic changes in customer demands, as the much tighter relationships between catch, industry and ex-Iceland customers makes customer specific adaptation both easier and less risky than it is for the Norwegian suppliers. We will return to these issues in the later experiments.

5.4 Destinations of Herring in the Exchange System – The Demand Side

Let us leave the countries making up the supply side of the herring industry and move on to their customers. If we take a very broad look at the end users of herring products, we will argue that the main destinations for herring today can be split in two distinct categories, and that the most salient differentiating factor between the two groups is the demands they put upon their suppliers.

The first of these is the supply structure connected to the supply systems of the large, modern retail chains. These tend to be more demanding towards their suppliers than customers that are not serving these retailers. In western countries, we have seen the market shares held by large retailers rise significantly over the last decades (see Marfels [1992] who examine this development in Germany), to the situation today where 'big retail' totally dominates food retailing in many countries. During recent years, the same development has been, and still is, taking place in the Eastern European countries, at an even higher pace. An effect of this is that the supply structure serving these retailers are more or less forced to accept very rigid demands on pricing, stable quality and timing of deliveries (Asche and Tveterås 2005; Bloom and Perry 2001; Collins 2002; Collins and Burt 2001). Industrial processing requires a higher level of standardization on input, better coordination towards suppliers and in general a higher level of adaptation to their needs in order to achieve efficiency in production. There are also indications that customers who buy products that are more highly processed tend to put higher demands on the supplier's ability to play a part in product and process innovation over time. The result of this is that both supplier and buyer in these systems benefit from having more stable relationships that allow for closer integration, better coordination and investments in product and process development. Based on the demands this group of customers put on their supply structure they will be defined in our study as *more demanding users*.

If we look at the export figures for herring from Norway, it is clear that the really big markets for herring today in terms of volume are Russia, Ukraine and Belarus. For the Norwegian exporters, these markets were "created" in the turmoil following the fall of the iron curtain around 1989-1990, as the Soviet fishing fleet fell into disarray and the borders opened. Consumers in these countries have traditionally bought their herring on markets with lots of small sellers, and the supply structure built up on serving this retail structure is still dominant in these markets. The end users these customers serve generally purchase products that have been through relatively little industrial processing, meaning that the demands on innovativeness in product development and process improvement are relatively low. This means that these customers will be less worried about switching between suppliers, as long as they are able to buy enough to fulfill customer demand. For a supplier, the less demanding customers can quite clearly be profitable, but they will not contribute to or drive product or process innovation. More importantly, this group is diminishing rapidly[4] as the retail structure changes and customers in these markets develop new preferences. Due to their relatively low demands on suppliers in terms of price stability, coordination and adaptation these customers are defined in our study, as *less demanding users*.

		Retail channel type	
		Modern Retail	**Traditional Retail**
Level of processing	**High**	**High**	**Medium**
	Low	**Medium**	**Low**

Figure 2: Customer demand classification

[4] If we are to be precise, less demanding customers as such are not really disappearing; they are simply becoming more demanding.

6 The Simulations Model

One of the basic assumptions in this paper is that it is not only possible, but also of interest to view economies as evolving complex systems (Anderson, Arrow, & Pines, 1988). In this paper, we have conceptualized networks as a type of exchange systems displaying a high level of complexity and comprising evolutionary processes (Prenkert & Hallén, 2006).

The main issue being addressed in this study is the interaction between different levels within an exchange system and the effects these interactions have on the development and effectiveness in terms of the accumulated exchange value of the exchange system as a whole and of its two constituent sub-networks. In this section we shall extract a set of variables and entities that describe a simplified model of the exchange system including the two cased sub-network(s) in a manner suitable for simulated experiments.

6.1 Constructing a Model World of the Exchange System

The construction of the simulations model can be likened to the creation of a small model "world" of the North Atlantic herring exchange system. The basic structure of this model

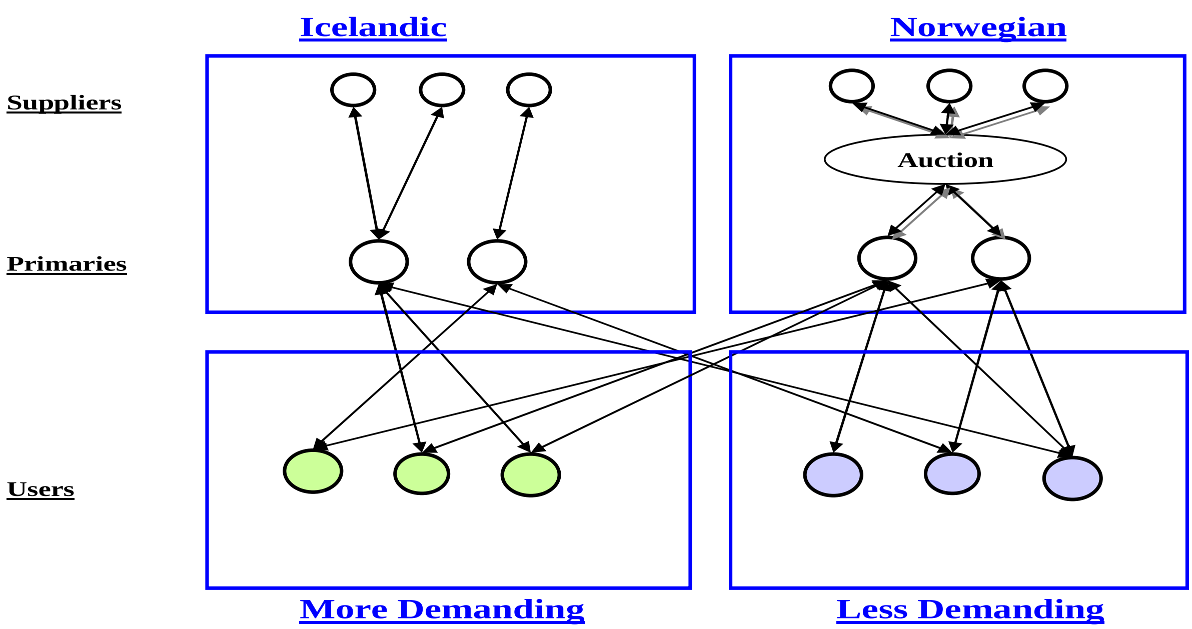

Figure 3. A Simplified Exchange System Model

world – or simply *model*, is found in **Figure 3**. This figure illustrates the two sub-networks of Iceland and Norway showing that on a structural level the main difference between the Norwegian and Icelandic sub-networks lies in the organization between the catch actors, primary processing actors and exporters. In contrast to the auction market organization found in Norway, the interaction between fleet and industry in the Icelandic sub-network is characterized by a high degree of vertical integration (70-90% of all vessels are integrated, meaning that primary processing takes place on-board the ship). In terms of ownership and control, the integration also incorporates the export function, which means that the Icelandic suppliers act as completely integrated companies towards their customers abroad.

As can be seen in **Figure 3**, the exchange system comprises a set of different actors and they are modelled as four different major *types* of actors. First, there are the **Suppliers** or the fishing vessels inserting herring into the system and interacting with primary processors through exchange of raw material for financial resources. Second, there are the **Primary processors/Exporters** that are all treated as integrated units in the model. This is a simplification that is realistic in some cases where these are indeed one company, but, as discussed previously, there are also a number of independent processors and exporters. For the purpose of this study, it is not necessary to distinguish between these two functions, and they will therefore be treated as one, labelled **Primaries**.

Third, there are the **Users**. The user is a representation of the demand structure faced by the Primary processor/Exporter, and it incorporates importers, secondary processors, distributors and retailers. Depending on destination this can be more or less complex. However, as the issues to be explored further in this study does not require that these different actors are treated separately, we will treat them as one integrated agent in order to simplify the model and the analysis of the results. What is needed (and included), as should be evident from the preceding discussions, is a separation between traditional and modern retail structures, as this has clear implications on the demands faced by the two sub-networks.

Finally, there are the **Relationships**. In order to make the relationships “come alive” in the simulated world, they will be conceptualized as agents. This allows them to evolve over time depending on the activities of the two parties involved in the relationship. It also opens up for using the relationships more actively when dealing with issues that are connected to the specific interaction between two actor agents – a highly valuable possibility.

Furthermore, the simulations model is based on a large number of assumptions regarding the mechanisms and the functioning of the exchange system it is set out to model. These are summarized in **Appendix I**, and functions as the rules and condition that "power" and control the model. When the simulation is run, it is done so following a certain *a priori* defined sequence. For each time-period the same specific sequence of code is run. This sequence is important, as any change in it will lead to a change in outcome. **Appendix II** provides a detailed description of the sequencing of the simulations model.

6.2 The Dependent Variable

As discussed earlier, the dependent variable used in our experiments based on simulations of the exchange system was chosen as the accumulated exchange value on the supply structure level. This is measured by adding up the realized exchange value for all primaries belonging to the supply structure during the simulation run. The reason for this choice is that it enables us to address our problem in an effective way by systematically manipulating some of the basic conditions of the exchange system relating to our inquiry and to measure the impact of this manipulation in the accumulated exchange value of the two supply structures. This gives us an indication on how the exchange system reacts to the shifts in the basic conditions which we aim to investigate, measured as changes in the creation and distribution of value in the system.

6.3 Quality

Quality is a key concept in this study as it denotes the potential of a resource in terms of the services that it can render a user with which it is exchanged (see also section 4.1 for the conceptual underpinnings of this assumption). In the simulated world, quality is used to denote the state of the resource being traded. It is implemented as a very simple measure – a single variable taking on a value from 0 to 100 is used. This value does not indicate good or bad quality *per se*, but differences in the services rendered by the traded resources. Resources traded in the simulation are heterogeneous, and the value of a resource is not independent on who valuates it. For the users, the value of the quality parameter is an indicator of how close the product is to their preferences for this kind of resource. These preferences are formed as a function of the demand they are facing from the end user (consumer) of the resource, and the structures(s) of other resources and activities the traded resource will interface with in order to be transformed into different end states. For the primary, the key is to match the quality of supplied raw material with the demand for specific qualities from users. The closer they get in this matching, the higher the value for the user and, thus the higher the realized exchange value. The same applies to the supplier: The better the match between the quality of their offer and the quality preference of the primary (which is a function of quality demands from the users they are trading with), the higher the realized exchange value.

6.4 Simulation Model Testing

The simulation model was devised in accordance with the problem at hand so as to enable us to track the development of the accumulated exchange value in relation to a systematic manipulation of some basic conditions of the exchange system. Based on case data, the simulations model comprises two principal types of customers of primary processors termed less and more demanding dependent on the level of quality that these actors require. As a result we devised experiments to track the development of accumulated exchange value in the four combinations of sources of supply and level of quality demanded by users depicted in **Figure 3**.

In our main experiment, we ran simulations in which we systematically manipulated some of the conditions controlling the functions of the exchange system represented by the simulations model. These conditions are the information processed in the model through the mechanisms of the exchange system and which creates variation in the dependent variable.

Although the simulations model in itself allowed for much more complicated simulations, we choose to reduce complexity by focussing the experiment as described above. The experiment was devised so as to simulate a shift in the demand structure where the number less demanding user group go down and the number of more demanding users go up, making the average user become increasingly more demanding. This simulation was combined with experiments where the quality-demand level of the more demanding group increases, further increasing the average quality demand.

However, the first step is to create a “baseline” scenario. This is constructed to create equal conditions of the variation in origin of the herring (Norwegian or Icelandic), resulting in average equal exchange value accumulation. This means essentially that origin should have no impact on the dependent variable. This is a way to test the model structure and make sure that it works properly in terms of the mechanisms controlling the dependent variable, and to create a basis for comparison for the subsequent experiment. Baseline scenario testing results are reported in the following section.

7 Simulation

Before testing for performance under different conditions for the two supply structures, we will take a look at how they perform under equal conditions. This will form the baseline for judging the effects of the following experiments against. The differences between the two structures are; a) while the Icelandic primary agents are supplied by one or more supplier agent that is dedicated to them, the Norwegian primary agents are sourcing through an auction system, b) the Icelandic supply structure has half the raw material input of the Norwegian structure, and c) the number of Icelandic primaries is half the number of Norwegian primaries. This means that the *average* volume handled by each primary will be the same, regardless of which supply structure it belongs to. Average input quality is set to be equal for the two supply structures, at a value of 30.

Also, the two groups of users are assumed to be different in some ways. Firstly, while the average size of users is the same for each group, the number of less demanding users is set to be three times the number of more demanding users. This means that 75% of total demand comes from less demanding users. This reflects what we will term a pre-demand-shift situation, where the traditional structure of less demanding buyers makes up the largest group. Furthermore, the users within the two groups differ in the following ways:

Table 1. Differences Between Less and More Demanding Users

	Less demanding	More demanding
Demanded Quality	40	60
End-user value put on demanded Quality	45	70
Cost of adapting quality	0.5	1.0

As **Table 1** shows, more demanding users are assumed to have a higher cost of adapting quality, as well as a higher demand for quality from their customers, the more demanding end users. This is balanced by a significantly higher end user price attained for this higher quality level. The relative values for less and more demanding users are set so that the resulting price for the initial quality level is equal for the two user groups, while the payoff for supplying a quality closer to the demanded quality will be higher for the more demanding user group.

The baseline scenario has absolutely no uncertainty connected to the quality and quantity of herring input to the two supply structures. As we have touched upon earlier, the level of uncertainty (or stochastic variation) is expected to have a different impact on accumulated exchange value for the two supply structures, and we will therefore in the following section look at the sensitivity of accumulated exchange value and relationship strength to different levels of input uncertainty.

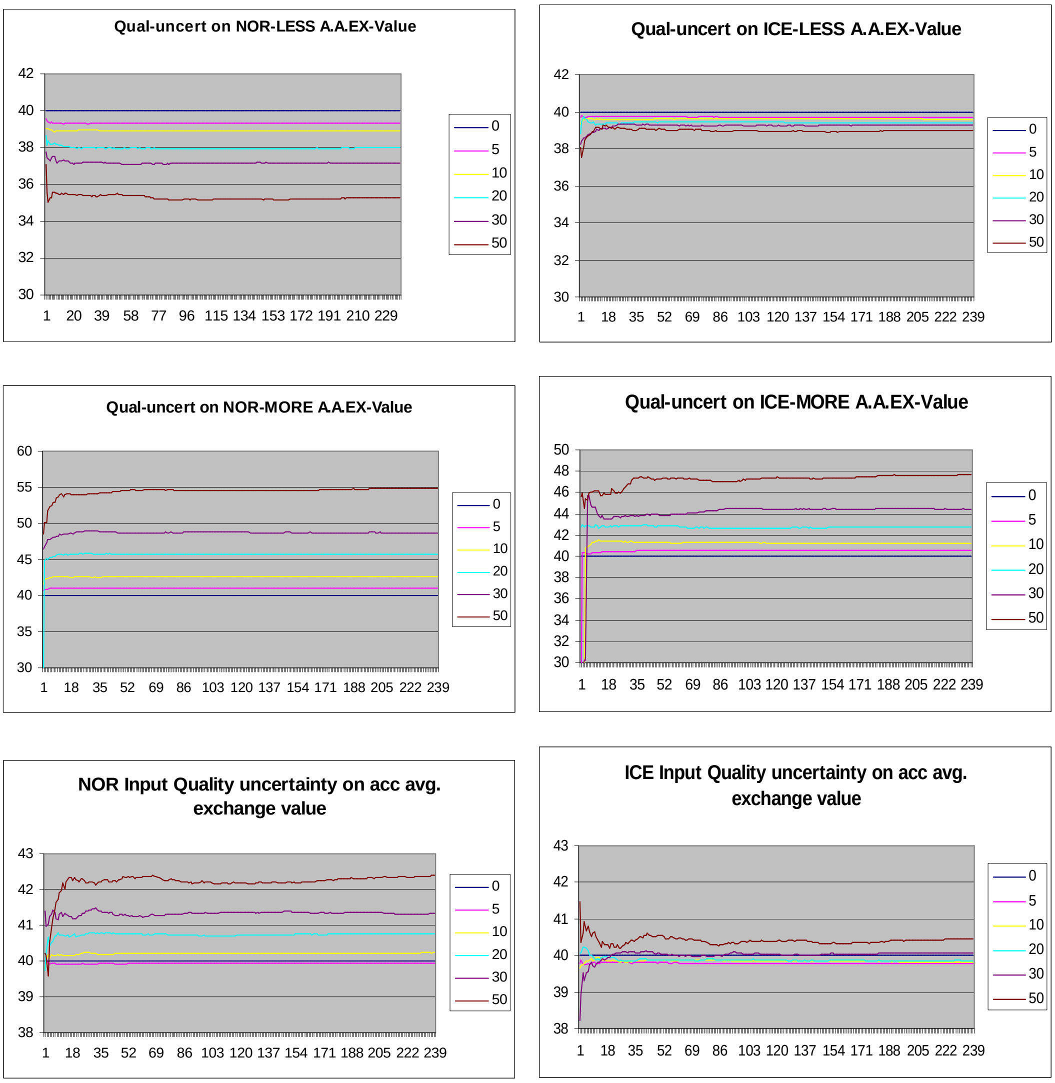

Figure 4. The Effect of Input Quality Uncertainty on Accumulated Exchange Value for Less Demanding, More Demanding and All Users

As the graphs in **Figure 4** above indicate, the effects of input quality uncertainty on accumulated exchange value are partially different for primaries belonging to the two structures. Common for both supply structures is that under these conditions, an increase in quality uncertainty will reduce exchange value from less demanding users and increase it from more demanding users. The degree differs however, and while the overall effect is positive for both structures, the impact is much larger for the Norwegian primaries. This is expected, and it shows that under these conditions the auction market system of the Norwegian structure is superior in matching a higher level of heterogeneity on input quality with the heterogeneity represented by the two different demand-structures.

We also tested for different levels of uncertainty on input volume, but this proved to have a very weak effect on relationship strength and no effect on accumulated exchange value, and the resulting graphs are therefore omitted to save space.

7.1 A Simulated Experiment – The Effects of Demand Structure Shifts

From our empirical study it is clear that the changing retail structure is playing an important role in transforming user structure of herring and creating a change in demands on the supply structure in the exchange system. The shift from a situation with a high number of small retailers to a small number of very large and powerful retailers means that the sub-networks serving retail are forced to adapt to retailer demands. Given the observed shift in key user destinations of herring from a traditional structure that has been less demanding in terms of stability to a modern retail structure that is highly demanding, the second main issue occupying us in this paper is what happens with the distribution, creation and accumulation of accumulated exchange value in the two sub-networks, when the demand from users increases?

The experiment is designed to test for the effects of a shift in the demand structure that resembles the shift we have seen in western countries over the past couple of decades. To do this we first created a situation where the demand volume shift from 25% from more demanding users to 75% from more demanding users over the simulation period of 20 years (240 periods). The second part of this experiment focuses on the introduction of an increase in the end-user quality demand in the more demanding group. These two shifts are first tested for separately, and then in combination, and in the figures below we show the more interesting effects on the dependent variables from the demand shifts. Due to the importance of input quality uncertainty we will include this variable in the subsequent experiments, testing and reporting the results for low (0%), moderate (10%), and high (30%) levels of input quality uncertainty. Let us first examine the results of introducing a shift in quantity from less to more demanding users.

7.1.1 Volume Shift from Less to More Demanding Customers

As the graphs in **Figure 6** show, a shift in demand from less to more demanding customers alone does not have a significant impact on exchange value for either of the two supply structures. This is as expected, and happens because the two demand structures have the same exchange value potential throughout the run.

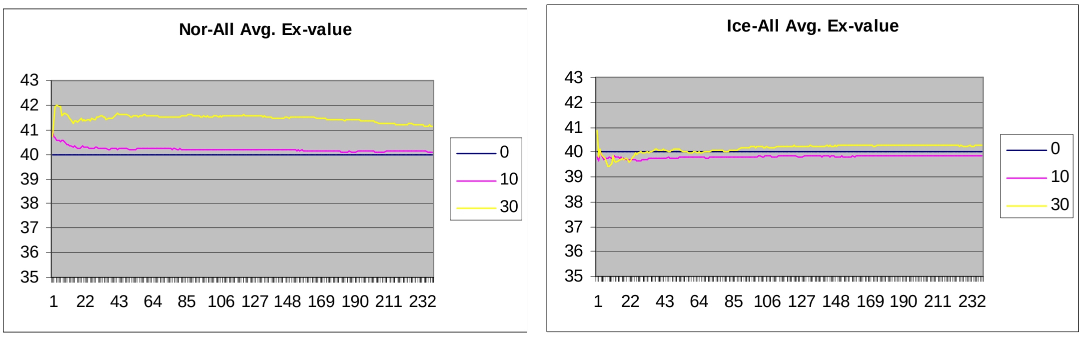

Figure 6. The Effects of a Shift of Volume from Less to More Demanding Users

As we have seen before, a higher level of input quality variation significantly increases exchange value accumulation throughout the run for the Norwegian structure, while the effect on the Icelandic structure is negligible.

7.1.2 Quality Demand Increase from More Demanding Customers

As expected, introducing a shift in quality demand for the more demanding group of customers has an impact on the exchange value realized trading with this group (see **Figure 7**). However, this impact is isolated to the Norwegian supply structure; the Icelandic primaries are not affected in the same way.

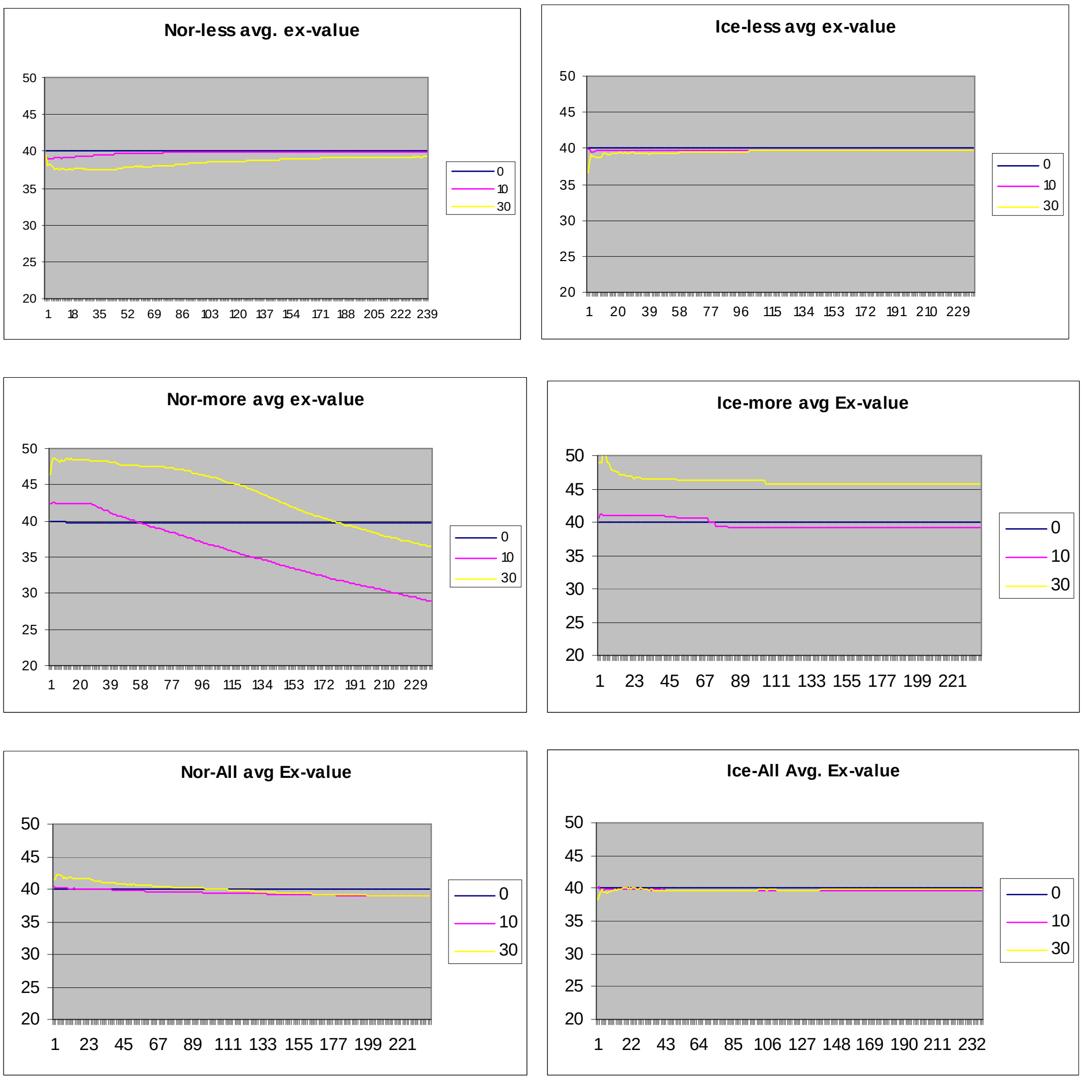

Figure 7. The Effects of Increasing Quality Demands from More Demanding Users

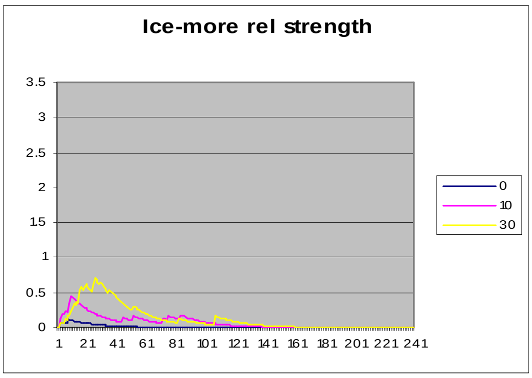

Figure 8. Quality Shift Effect on Icelandic - More Relationships

The reason is found in examining the relationship strength graph (see **Figure 8**) and the exchange value for the "Ice-more" combination: Under a situation of high supply quality uncertainty the Icelandic primaries behave opportunistically – trading with the more demanding customers when they have a particularly high quality batch to sell. Failing this, and as the more demanding customers demand increasingly higher quality, the stop trading with this group and focus entirely on the less demanding, and more profitable, customers. The Norwegian primaries do not have this option – to find a market for all their products they are forced to continue trading with the more demanding customers even as these become increasingly more demanding and pay less for a product that is further away from the desired state.

7.1.3 Volume Shift from Less to More Demanding Customers Combined with Increasing Quality Demands from More Demanding Customers

As the **Figure 9** shows, introducing both shifts in the simulation has a dramatically stronger effect than any of the shifts alone. Under this scenario, the opportunistic

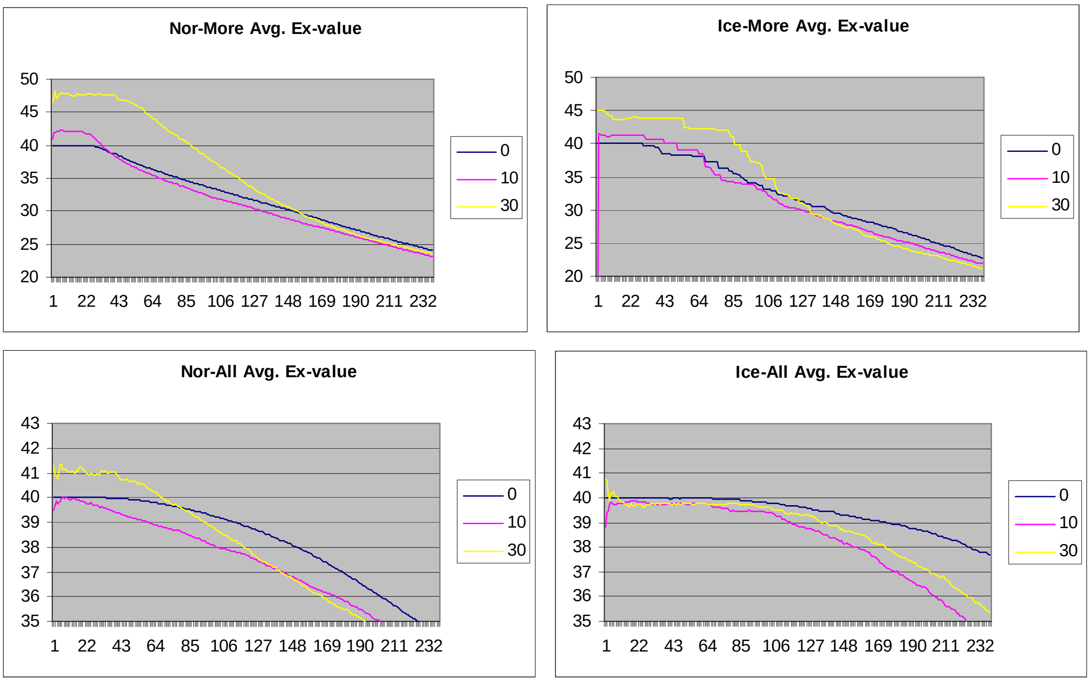

Figure 9. Shifts in Quantity from Less to More *and* an Increase in Quality Demand from More Demanding Users

strategy of the Icelandic primaries is no longer viable to the same extent as it was when only quality demand shifted. As the more demanding group grows, the Icelandic primaries are no longer able to focus on the less demanding customers alone, and are hurt by the decrease in willingness to pay for an increasingly inferior product by the more demanding customers. This effect is on average even stronger for the Norwegian primaries

8 Discussion

We will not attempt to draw any extensive conclusions on the effects of demand-side shifts from the simulated experiments presented here. What we have shown is a way of utilizing simulations as a tool to gain a deeper understanding of the dynamics of exchange systems. Results are entirely dependent on the assumptions made, and as such what we have done is a form of theoretical modelling.

We can however, conclude that different organization within a sub-section of an industrial network does have an impact on the value creation potential of members of this subsection as the conditions under which it operates changes. Also, our model illustrates the differences in impact of uncertainty on raw material input quality into differently organized supply structures. Clearly, the organization of the sub-networks matters in relation to the realization and distribution of value among its members as well as between the two structures. Some types of organization are more adaptive to some changes in conditions and are better suited to absorb such changes compared to other types of organization.

8.1 Contributions and Directions for Further Work

This paper presents a possible approach to simulating an exchange system in order to gain further insight into the mechanisms that contribute to the creation and distribution of value. It is the translation of theoretically and empirically founded mechanisms into a formal and quantified model that allows for experimental testing of theory that is the main contribution of the work presented here lies. This is based in our realization that even though the work presented in this paper represents an important contribution to the understanding of industrial networks, it is clear that this is merely a beginning.

More work is needed in order to include other core elements of the exchange system into the model. Two such elements are relationship specific adaptations to shifts in customer demands and differentiated abilities to adapt to customer demands based on previous buyer-sell interaction. Preliminary experiments with models including these elements indicate that the exchange system is highly sensitive to variation in these elements, and that such an extension of the model dramatically changes the appropriation patterns of exchange value.

Furthermore, while we have gone some ways in investigating the effects of demand shifts, we have not looked at the effects of a shift in supply from one structure to the other. It would clearly be interesting to look further into the effects of a shift in access to raw material from the now dominant Norwegian structure to either the Icelandic structure, or to a competing structure based on Norwegian raw material, but organized as the Icelandic structure. Both are possible future scenarios, and as the implications for the current Norwegian supply structure would be significant under such scenarios, this would clearly be a worthwhile study to pursue.

Finally, we recognize the challenge in presenting both model and results in the relatively brevity required by the paper format. This has lead us to exclude a number of results that would clearly have enriched the understating of the model for the reader, but is simply to space-consuming to include. This is unfortunate, but on the other hand it does leave us with a number of paths to explore in future papers.

Appendix I: Assumptions about Mechanisms and Functions of the Simulations Model of the North Atlantic Herring Exchange System

- 12 periods constitute a year in the simulated world. Each simulation run will have to be a number of periods long that is dividable by 12. All simulation runs reported in this paper runs for 240 periods, or 20 years.
- The total world consists of four areas; two supply areas (Called “Norway” and “Iceland”) and two demand areas. (Called “Less demanding” and “More demanding”) There is no economic activity between supply areas or between demand areas.
- Each supply area has a number of suppliers (extracting the raw material) and a number of industrial actors (performing primary processing of the raw material). These are termed “Suppliers” and “Primaries”.
- One of the demand areas contains a number of less demanding “Users” of products offered by the raw material, while the other contains a number of more demanding users. These are distinguished by how they value offers from suppliers.
- Agents are connected in two ways:
    - Direct interaction. Interaction takes place in the form of trade between suppliers and primaries, and primaries and users.
    - Through “Relationship” agents. These are represented as agents in the model, and they function as a memory of past interaction between the two agents they connect, as well as a facilitator for the direct interaction between buyer and seller.
- There are no horizontal connections in the world (supplier – supplier, primary – primary, or user – user)
- Icelandic suppliers interact with only one primary, creating an vertically integrated supply structure. Icelandic primaries can have many suppliers.
- Norwegian suppliers interact with all Norwegian primaries, and Norwegian primaries interact with all Norwegian suppliers.
- All primaries can interact with all users.
- Primaries have a processing capacity that is relative to the supply on a 12 period (yearly) basis. The capacity will be calculated a the beginning of each run and will thereafter be recalculated every 12 periods to reflect the average monthly supply for the coming 12 periods.
    - Norwegian primaries will have a capacity that is based on the capacity of the total Norwegian supply fleet:
      Primary-capacity = (∑capacity-norwegian-suppliers / number-of-norwegian-primaries) + over-capacity
    - Icelandic primaries will have a capacity that is based on the supply fleet the individual primary owns:
      Primary-capacity = ∑capacity-owned-suppliers + over-capacity
- Primaries have an overcapacity of 100%. This is relative to their share of total capacity, and means that the total processing capacity is twice the yearly supply of raw material.
- For each period, exchange between two parties (who are connected through a relationship) will only happen once.
- Relationship strength between primaries and users is a function of the stability of interaction between primary and user. For each period with a trade between a primary and user, the relationship strength increases by a fixed number (e.g., Strength + 2). To counter this, with each period (regardless of trade/no trade) the strength decreases with a factor (e.g., Strength x 0.1) as a function of time passing. This means that a relationship can grow fast in the beginning, but that it will reach a plateau after some periods above which it will not go.
- Primaries are assumed to be optimistic in their estimation of demand. Based on the sales for the previous period, they will always estimate that they will sell 50% more in the coming period.
- There is an over-demand of 25% relative to the available supply of raw material. This means that exchange volumes may shift from one user group to another depending on the value realized in exchange to members of two groups.

Appendix II: Sequencing of the Simulations Model

Step	What	Comment
0	Set period counter + 1	
1	Reset agents	
1.1	Reset actor agents	Sets sales, revenue, sold-out status etc. to 0
1.2	Reset relationships	Resets intra-period variables for relationship, reduces strength to account for fading over time
2	Recalculate Primaries Capacities	Done every 12 periods (for the coming 12 periods)
3	Set Preferences	Systematically runs through all agents to establish what they want to buy and sell
3.1	Set user preferences	
3.1.1	Read demand-data from list	
	Distribute demand based on market sizes and shares	
3.1.2	Calculate desired quality and quantity	
3.2	Set primaries preferences	
3.2.1	Calculate desired quality and quantity	Based on last period
3.3	Set supplier preferences	Not in use
4	Reset Globals	Resets the global intra-period counters to 0 to prepare for next run. (Done after preference-setting because there are variable-values used for setting preferences that are reset in this step)
5	Run Suppliers	Sequence Nor vs. Ice not an issue, as they are not competing for the same resource or customers. All suppliers will finish before primaries are run.
5.1	Run Norwegian Suppliers	
5.1.1	Norwegian suppliers catch fish	
5.1.1.1	Read this periods catch-data from list	
5.1.1.2	Set quantity of catch	
5.1.2	Norwegian Suppliers sell fish to primaries	
	Set starting price	A fixed price reflecting the minimum price
5.1.2.2	Ask primary for bid	Repeated for all with fish to buy (perfect info implied)
5.1.2.2.1	Primaries calculate bid value	Value is added/subtracted based on offered quality. Value is added if primary is underutilizing capacity.
5.1.2.2.2	Highest bid value so far?	If yes, set as best bid. (Register value, quantity, quality, buyer)
5.1.2.3	Sell to bidder with highest value bid	Updates the buyer with financial and goods movements
5.1.2.4	Update seller	Updates the seller with financial and goods movements
5.1.2.5	Update relationship	Updates trade-info and relationship info in relationship. Increases strength of relationship if this is activated
5.1.3	Sell remains	Remaining fish is sold of to non-human consumption (lower price/price =0).
5.2	Run Icelandic suppliers	
5.2.1	Icelandic suppliers catch fish	
5.2.2	Icelandic Suppliers sell fish to primaries	
5.2.2.1	Calculate price	
5.2.2.2	Sell to owner	Updates the buyer with financial and goods movements
5.2.2.3	Update seller	Updates the seller with financial and goods movements
5.2.2.4	Update relationship	Updates trade-info and relationship info in relationship. Increases strength of relationship
5.2.3	Sell remains	Any remaining fish is sold of to non-human consumption (lower price/price =0).
6	Run Primaries	Needs to be run in random sequence as primaries from different countries compete for the same buyers
6.1	Primaries sets purchase price	Calculates the average purchase price of the fish they have to sell. This is the foundation of the starting-price when selling
6.2	Relationships calculate value	Primary-user relationships calculate the value of the
6.2.1	Set sort order	Relationships are sorted so that the relationship with the highest value offer gets executed first, the the second highest etc.

6.3	Primaries sell fish	
6.3.1	Current highest value relationship is executed	Until either all fish is sold or there is no more demand in period, the relationship with the highest value with a) a seller with fish to sell, and b) a buyer with fish to buy is executed. Each relationship can only be executed once each period.
6.3.2	Update seller	Updates the seller with financial and goods movements
6.3.3	Update relationship	Updates trade-info and relationship info in relationships. Increases strength of relationship if this is activated
6.4	Primary store fish	If storage is enabled and fish is left unsold, this is carried over to the next period
7	Run User	
7.1	Evolve user preferences	
8	Update global variables	Global variables are updated with this periods data. These globals are used for plotting and written to files

References

Alchian, A. A., & Demsetz, H. (1972). Production, Information Costs, and Economic Organization. *American Economic Review, LXII*(December), 777-795.

Alderson, W. (1957). *Marketing Behavior and Executive Action: A Functionalist Approach to Marketing Theory*. Homewood, Ill.: Richard D. Irwin.

Alderson, W. (1965). *Dynamic Marketing Behavior: A Functionalist Theory of Marketing*. Homewood, Ill.: Richard D. Irwin.

Alderson, W., & Martin, M. W. (1965). Toward a Formal Theory of Transactions and Transvections. *Journal of Marketing Research, 2* (May), 117-127.

Anderson, J. C. (2004). From Understanding to Managing Customer Value in Business Markets. In H. Håkansson, D. Harrison & A. Waluszewski (Eds.), *Rethinking Marketing: Developing A New Understanding of Markets* (pp. 137-159). Chichester: Johnn Wiley & Sons.

Anderson, J. C., & Narus, J. A. (1998). Business Marketing: Understand What Customers Value. *Harvard Business Review* (November-December), 53-65.

Anderson, J. C., & Narus, J. A. (2004). *Business Market Management: Understanding, Creating and Delivering Value* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Anderson, P. W., Arrow, K. J., & Pines, D. (Eds.). (1988). *The Economy As An Evolving Complex System* (Vol. V). Oxford: Westview Press.

Asche, F., & Tveterås, R. (2005). Organisering av verdikjeder for sild og torsk. Stavanger: Universitetet i Stavanger. (In Norwegian).

Axelrod, R. (1997). The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration. Princeton, N.J.: Princeton University Press.

Blankenburg Holm, D., Eriksson, K., & Johanson, J. (1999). Creating Value Through Mutual Commitment to Business Network Relationships. *Strategic Management Journal, 20* (5), 467-486.

Blois, K. J. (2003). Using Value Equations to Analyse Exchanges. *Marketing Intelligence & Planning, 21* (1), 16-22.

Blois, K. J. (2004). Analyzing Exchanges Through the Use of Value Equations. *Journal of Business and Industrial Marketing, 19* (4), 250-257.

Blois, K. J. (1999). Relationships in Business-to-Business marketing - How is their Value Assessed? *Marketing Intelligence & Planning, 17* (2), 91-99.

Bloom, P. N., & Perry, V. G. (2001). Retailer Power and Supplier Welfare: The Case of Wal-Mart. *Journal of Retailing, 77* (3), 379.

Böhm-Bawerk, E. V. (1888). *The Positive Theory of Capital* (W. Smart, Trans. English 1891 ed.). New York: G. E. Stechert & Co.

Collins, A. (2002). The Determinants of Retailers' Margin Related Bargaining Power: Evidence from the Irish Food Manufacturing Industry. *International Review of Retail, Distribution & Consumer Research, 12* (2), 165.

Collins, A., & Burt, S. (2001). Dependency in Manufacturer-Retailer Relationships: The Potential Implications of Retail. *Journal of Marketing Management, 15* (7), 673.

Day, G. S. (1999). *Market Driven Strategy*. New York: The Free Press.

Dubois, A., & Araujo, L. (2004). Research Mehods in Industrial Marketing Studies. In H. Håkansson, D. Harrison & A. Waluszewski (Eds.), *Rethinking Marketing: Developing a New Understanding of Markets* (pp. 207-227). Chichester: John Wiley & Sons.

Dubois, A., & Gadde, L.-E. (2002). Systematic Combining: An Abductive Approach to Case Research. *Journal of Business Research, 55* (7), 553-560.

Fjeldstad, Ø. D., & Ketels, C. H. M. (2006). Competitive Advantage and the Value Network Configuration: Making Decisions at a Swedish Life Insurance Company. *Long Range Planning, 39* (2), 109-131.

Gilbert, G. N. & Troitzsch, K. G. (1999). Simulation for the Social Scientist. Buckingham: Open University Press.

Håkansson, H., & Prenkert, F. (2004). Exploring the Exchange Concept in Marketing. In H. Håkansson, D. Harrison & A. Waluszewski (Eds.), *Rethinking Marketing: Developing a New Understanding of Markets* (pp. 75-97). Chichester: John Wiley & Sons.

Johanson, M., & Wedin, T. (2000). *Value Creation in Industrial Networks.* Paper presented at the 16th Annual Industrial Marketing and Purchasing (IMP) Group Conference, Bath, UK.

Marfels, C. (1992). Concentration and Buying Power: The Case of German Food Distribution. *International Review of Retail, Distribution & Consumer Research, 2* (3), 233.

Marx, K. (1845/1967). Theses on Feuerbach. In E. Kamenka (Ed.), *The Portable Marx*. New York: Penguin Books.

Marx, K. (1964). *Economic and Philosophical Manuscripts of 1844*. New York: International.

McInnes, W. (1964). A Conceptual Approach to Marketing. In R. Cox, W. Alderson & S. J. Shapiro (Eds.), *Theory in Marketing*. Homewood, Ill.: Richard D. Irwin.

Menger, C. (1871). *Principles of Economics* (J. Dingwall & B. F. Hoselitz, Trans. English 1976 ed.). New York and London: New York University Press.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis. An Expanded Sourcebook* (2^{nd} ed.). Thousand Oaks, Cal.: Sage Publications.

Morgan, G., & Smircich, L. (1980). The Case for Qualitative Research. *Academy of Management Review, 5* (4), 491-500.

Normann, R., & Ramírez, R. (1993). From Value Chain to Value Constellation: Designing Interactive Strategy. *Harvard Business Review,*(July-August), 65-77.

Normann, R., & Ramírez, R. (1994). *Designing Interactive Strategy: From Value Chain to Value Constellation*. Chichester: John Wiley & Sons.

Penrose, E. T. (1959). *The Theory of the Growth of the Firm*. Oxford: Basil Blackwell.

Pettigrew, A. (1997). What is Processual Analysis? *Scandinavian Journal of Management, 13* (4), 337-348.

Porter, M. (1985). *Competitive Advantage*. New York: The Freee Press.

Porter, M., & Millar, V. (1985). How Information Gives You Competitive Advantage. *Harvard Business Review* (July-August), 149-160.

Prenkert, F., & Hallén, L. (2006). Conceptualizing, Delineating and Analyzing Business Networks. *European Journal of Marketing, 40* (3/4), 384-407.

Ragin, C. C. (1992). 'Casing' and the Process of Social Inquiry. In C. Ragin & H. S. Becker (Eds.), *What is a Case: Exploring the Foundations of Social Inquiry*. Cambridge: Cambridge University Press.

Ragin, C. C. (2000). *Fuzzy-set Social Science*. Chicago, Ill.: University of Chicago Press.

Ravald, A., & Grönroos, C. (1996). The Value Concept and Relationship Marketing. *European Journal of Marketing, 30* (2), 19-30.

Shaw, A. W. (1912). Some Problems in Market Distribution. *Quarterly Journal of Economics, 26,* 703-765.

Stabell, C. B., & Fjeldstad, Ø. D. (1998). Configuring Value for Competitive Advantage: On Chains, Shops, and Networks. *Strategic Management Review, 19* (5), 413-437.

Weld, L. D. H. (1916). *The Marketing of Farm Products*. New York: Macmillan.