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Theme A

NETWORKS, INFORMATION, AND THE CREATION OF MARKETS

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Abstract

This paper deals with two issues concerning the relation between information and the existence and nature of industrial networks. First, it relates to the coordination, transfer, and assessment of information acquired and possessed by different firms. Second, it addresses the non-existence of future markets and the role of the network in aligning plans and thereby reducing the uncertainty about future needs, technologies, preferences, and product specifications. It is argued that the organizational form of networks achieves a more efficient way of gathering and assessing complex and relevant information compared to other organizational forms. The proposition developed in this paper suggests a higher level of exchange of complex and relevant information in network relationships in comparison to other types of inter-firm relationships. Empirical evidence from 4842 inter-firm relationships confirms the proposition.

Keywords: Division of labor, Information, Inter-firm networks, Markets, Uncertainty

JEL: D83, D84, L11, L15, L22, L23, L60

Introduction

This paper deals with two issues of the relation between information and the existence and nature of industrial networks. The first area concerns the coordination of information acquired and possessed by different firms. The second area relates to the non-existence of future markets (Arrow, 1974a; Loasby, 1996) and the role of the network[1] in aligning plans and thereby reducing the uncertainty about future needs, technologies, preferences, product specifications, and so forth. The focus of the paper is on the characteristics and nature of industrial inter-firm network as a form of economic organization counteracting the organizational failures of markets and firms. The purpose is to develop an economical approach to explain the existence and nature of industrial inter-firm networks from an information perspective.

A network is here defined as a set of long-term based interdependent dyadic inter-firm relationships between firms undertaking complementary activities for problem solving in product or process development. The relationships are established with the intention of a long-term base. However, relationships may be changed after a short period. The important distinction between networks and, for instance, project organizations and market relationships, is the initially intended time span of the relationship.

The problem solving refers to technological development that requires a variety of different capabilities that are individually possessed by several firms. Further, the relationships are characterized by, for instance, a high level of sunk costs mutually invested in the relationships, thereby lowering risk for specialization in activities and knowledge. Moreover, a low cognitive distance, as a result of close, long-term interaction, between firms enhances learning and the utilization of knowledge.

[1] In this paper there will be no distinction between an information or production network. Lundvall (1985) distinguished between linkages and information channels in inter-firm relationships. Linkages relate to production while information channels relate to innovation. Separation between information and production network does not seem valuable. Partly, because they overlap each other; there is always an information flow in production network; partly, because information from another firm or organization, which is not part of the production network, may prove to have significant impact on the production network, although indirectly. This may be important when considering public access to research and development centers external to the firm and production network. Such external R&D centers may be located at universities or governmental departments.

However, the mere contact between two firms does not automatically imply that they co-operate in the sense they are applying another coordination mechanism than the price. The level of co-operation may vary. A dyadic inter-firm relationship is here considered as an inter-firm relationship, which is more than an arm's length relationships as we recognize in a pure market relationship and less than the organizational form as we know as a firm.

Economies benefit from a division of labor between individuals and firms. The division of labor does improve the efficiency of the economy through a focused flow of information and development of knowledge and capabilities within specialized units. A network, viewed as a hybrid (Williamson, 1975, 1985) or a "vertical semi-integration" (Lundvall, 1985) combines the value of having coordination of information and knowledge within an organization with the efficiency of focused and specialized firms.

The positive effects of specialization, as an outcome of the division of labor, on the economy have been known, at least, since the work of Adam Smith (Smith, 1776). The basic argument is that increasing specialization in terms of labor and knowledge leads to increasing productivity. Specific knowledge and skills is argued to be developed more efficiently by focusing on a certain activity than a wide set of activities. Babbage (1835) emphasized the perspective of knowledge, although implicitly expressed in the theorem of Smith, and added the division of mental labor. Still today, the literature stresses the competitive dimension of specialization on certain economic activities, 'core activities', which leads to unique knowledge and skills (see e.g. Penrose, 1955, 1959; Wernerfelt, 1984; Barney, 1991; Peteraf, 1993; Prahalad & Hamel, 1990).

The division of labor is not only characterized by positive economic effects but also hampered under some structural constraints. The division of labor is limited by the extent of the market (Smith, 1776; Stigler, 1951). That is, further specialization may be undertaken as long as a market for these more specialized activities exists. More important, however, there is a contradiction between the increasing level of the division of labor and thereby the increasing division and dispersion of information and knowledge. If the degree of specialization increases there will also be an increasing

need for coordinating economic activities performed by a wide body of firms. Coordination is necessary to be able to transfer, accumulate, and utilize the information and knowledge acquired by others and the firm itself. This need for coordination under a certain level of stability is one reason why networks exist (Richardson, 1972, 1998). However, economic activities could also be coordinated through vertical integration or through arm's length market relationships. This paper will illuminate factors from an information perspective, which decide why a network is sometimes the preferred organizational form.

Hayek (1937) argues that the fragmentation of information is a problem similar to and as important as the problem of the division of labor when explaining the "spontaneous interaction of a number of people, each possessing only bits of knowledge, brings about a state of affairs in which prices correspond to costs, *etc*., and which could be brought about by deliberate direction only by somebody who possessed the combined knowledge of all those individuals." (*ibid*., p. 49). Information is dispersed, fragmented, and asymmetrically distributed (Hayek, 1937, 1945). The assumption that information is fully accessible for all actors in a market, which is the case for the neoclassical view of a market, is a paradox. The fact that information is dispersed and markets are characterized by asymmetrical information is the reason why entrepreneurs may make profits (Knight, 1921). If everybody had access to perfect information, neither profits nor losses would occur. Although some markets try to achieve perfect information, for instance, on financial markets, there will always be a true uncertainty[2] about the future (Knight, 1921). That is, it does not exist any perfect information about the goods, services, technologies, preferences, etc. that will exist tomorrow.

Under the neoclassical view of perfect competition characterized by arm's length relationships between firms offering products and services and firms buying, the price is the only way through which information is transferred. The information transferred

[2] Uncertainty is here defined according to the definition by Knight (1921), who means that uncertainty is an immeasurable uncertainty. A measurable uncertainty, that is, a known distribution of the outcome of a set of instances, is the definition of risk in the view of Knight (*ibid*.). Uncertainty arises from, for instance, imperfect foresight and the difficulties to solve complex problems (Alchian, 1950).

between buyers and sellers, between producers and users, between suppliers and customers, does typically only reveal the price for given quantities and for existing products and services. No information about unsatisfied present needs or anticipated future needs are transferred in the neoclassical market.

Sources and Locus of Innovation

Although the literature recognizes that product and process innovation is initiated from a variety of sources, the literature on new product development seems to have overemphasized the role of the manufacturer as the source of innovation. However, it is not only the manufacturers that are engaged in the development of new processes and new products, but also the suppliers, the customers, and the users (von Hippel, 1988).

In particular, von Hippel argues that the innovative firms are likely to develop new products and processes to take advantage of the high profits from their potential innovations (von Hippel, 1988). Firms -not only manufacturers- may also expect to benefit from the temporary monopoly control over innovations that allows them to earn higher than normal rent, and gain a higher share of the market (Schumpeter, 1976).

Moreover, firms can gain higher rents not only from innovation on the product itself, but can also benefit from other potential areas for innovation, such as the manufacturing process, the materials and components used, the design etc. In addition, the locus of innovation-related rents may differ (von Hippel, 1988) and that has often as a result the separation between the innovator and the user firm (Lundvall, 1985). Mansfield (1968) argues that both the firm producing a new commodity and the firm using it may both be regarded as innovators.

> *"In cases where the invention is a new piece of equipment, both the firm that is first to sell the equipment and the firm that is first to use it may be regarded as innovators. The first user is important because he, as well as the supplier, often takes considerable risk."* (Mansfield, 1968, p. 83)

Consequently, it is not only the information and knowledge acquired and accumulated by firms through a learning-by-doing process (Arrow, 1962, 1974) that is of relevance, but also the information and knowledge acquired through a learning-by-using process (Rosenberg, 1982; Arrow, 1974; Lundvall, 1985), and from external sources, such as research institutes. Learning-by-doing and learning-by-using processes involve specialized unique knowledge that can lead to small incremental changes but have a significant cumulative effect (Rosenberg, 1982).

The interaction between innovators and producers, and between producers and users are characterized by a process where exchanging of information and knowledge, involves many iterations, and constitutes a feedback loop which may result in new process and product developments (von Hippel, 1994, Rosenberg, 1982). The locus of innovation changes as a result in changes in the costs of acquiring the information needed for the problem solving process. The market for information is imperfect and involves transaction costs (Williamson, 1975) that lead to "resource losses incurred due to imperfect information" (Dahlman, 1979, p. 148).

The incremental cost required to transfer the information, often referred to as the "stickiness" of information, depends on the amount of information transferred, the nature of the information itself, and the choices made by the firm providing and searching for information. It is further argued that even when small amounts of information are required, firms may sometimes have to acquire related information and knowledge to be able to utilize it successfully (von Hippes, 1994).

Existing knowledge accumulated in a firm is crucial for the ability to recognize and assess the value of new information (Cohen & Levinthal, 1990). Although it is beyond the purpose of this paper to discuss and elaborate on the concept of capabilities based on the resource based view, it is important here to stress the crucial role of firm capabilities to acquire relevant information, make an assessment of the value of the information, and to make the best use of the information.

To summarize the discussion so far, information is fragmented and dispersed as a result of the division of labor. Firms acquire and possess different amounts of information of various qualities. Product and process innovations may be initiated by different firms depending on their individual assessment of potential innovation-related rents that may be earned, the cost of acquiring the information and knowledge needed for solving the technological problems related to the innovation, and, third, the accumulated information and capabilities required for the problem solving activities. Then, what makes networks sometimes more efficient than other organizational forms, exchanging and transferring relevant information needed for coordinating complementary activities at a lower cost?

Relevant and Complex Information

For innovations, important information consists of the needs and wants of manufacturers, suppliers, customers, and users. These needs and wants reveals something about the future and might eventually generate ideas for innovations. Lundvall (1985) argues that innovations are "the result of collisions between technical opportunity and user needs" (*ibid.*, p. 3) and that innovating firms need information about both technological opportunities and user needs. Manufacturers, suppliers, customers, and users are obviously important sources of relevant information and knowledge concerning the development of new ideas and methods of problem solving, whether it concerns changing existing products and processes or developing totally new. Relevant information is here defined as the information, which is relevant to a particular firm. The information that may be categorized as relevant is then dependent on each individual firm under certain conditions, such as time. That is, at a given time, some information might be without value for one firm while of significant value for another firm. Moreover, it is important to distinguish between a regular flow of information from the production process, which might be considered as a routine process, and the irregular flow of information characterizing the innovation process. The outcome of the latter is much more uncertain although both processes are interdependent.

How can an efficient system of information transfer and exchange be obtained if relevant information is individually conditioned? Let us compare a market with arm's

length relationships and a network with a set of long term and stable relationships. It is obvious that firms in a market under such conditions do not know what information that is of significant to whom (except for the own organization) and the information transferred through the market price will likely be the only fragments of information that is required for problem solving processes. Thus, the amount and quality of the information transmitted through the price-mechanism is limited and contains, in principle, only prices for given goods and services. Actors on the market of arm's length relationships only have to know their own needs (Arrow, 1974).

On the other hand, firms in a network learn over time about the information needs of the other firms. Although they may not develop a perfect transfer of information, they establish over time a code of conduct in terms of information handling and transfer through the coordination of their complementary activities. What is relevant for one firm becomes more clear and known to the other firms in the network. Further, firms specialized in specific economic activities have better ability to search, assess, and select relevant information and knowledge related to those activities. A closer relation between manufacturers, suppliers, customers, and users promote the information transfer of relevant and complex information acquired through learning-by-doing and learning-by-using (Lundvall, 1985; von Hippel, 1988, 1994), and lower the costs for searching and assessing information (Dahlman, 1979, von Hippel, 1994). Thus, it is here argued that networks make information handling more efficient compared to the arm's length relationships on the market. Each firm in a network individually "selects" the relevant information and focuses on the transfer of this part of the total flow of information only (Arrow, 1974b), based on the knowledge of the relevant information related to the firm's own activities and the relevant information related to the complementary activities of the other firms in the network. That is not to say that not more information than needed is transferred. On the contrary, sometimes more information needs to be transferred than what is actually used (von Hippel, 1994).

Further, the benefit of coordinating activities undertaken by specialized firms in a network, rather than integrating the same set of activities within a single firm is the competitive "pressure" on each individual firm. Departments within a firm, with the

same specialization as firms in a network, will not experience the competition faced by individual firms on the market. Miles and Snow (1992) argue that the risk of failure for a network organization is the development towards a complete utilization of the firms' resources within the network. By undertaking activities coordinated with firms outside the network, a risk of a "lock-in effect" in terms of hampering development and acquisition of information, knowledge, and capabilities can be eliminated since outside competition forces firms within a network to continuously develop a sustainable competitive advantage.

Another factor for the emergence of networks is the problem of assessing the quality of output offered on the market. Buyers have less information about the quality of products offered than the sellers have. Prices alone do not provide the information about qualities and, consequently, there is an fundamental information asymmetry between buyers and sellers (Akerlof, 1970). Akerlof argues that, theoretically, poor quality products tend to drive out good quality products from a market and eventually drive the market out of existence. This may occur while the price for good as well as poor quality products will be the same, since buyers can't distinguish between products of good or poor quality until after the purchase. Sellers of good quality products are locked in since they will not receive the 'true value' of their products and, thus, the average quality level of the products offered in the market will decrease. Consequently, the ex ante probability estimated by the buyer, that he or she might get a poor quality product, increases and thus limits the demand. The market reduces in size and, eventually, reaches a situation where no trade occurs at all, at any price. However, although theory predicts the cessation of markets, markets still prevail. They do not in general tend to cease to exist due to lower quality and, as a result, lower demand. Akerlof (1970) argues that governmental intervention or private institutions, such as guarantees, licensing, chains, and brand names, emerge to counteract the uncertainty about the level of quality of goods offered in a market.

The uncertainty of quality may imply the existence of networks. Networks may act as an assurance of quality in two respects. First, by engaging in a network relationship firms expect a minimum quality level provided by the other firms. Firms would

probably not establish a relationship if a certain level of quality was not achieved by the other partners, Moreover, it would be costly for a firm to be "expelled" from a network due to poor quality, since the firm would make the investment sunk in the relationships worthless. Second, the quality reputation of a firm in a network may spillover to the other firms considering information accessed by potential partner firms or customers external to the network.

Akerlof's (1970) explanation of the nature of markets is fundamentally a critique against the neoclassical view that information is symmetrically distributed and known to everyone in a market. The application of the theory, however, is directed towards markets with a large number of both sellers and buyers. The incentives to market poor quality products, opportunistic behavior (e.g. Williamson, 1985), will most likely occur to a higher extent in markets where sellers are able to find new customers. While the costs of establishing and maintaining institutions like those discussed here may be classified as transaction costs, the costs of "dishonesty" (Akerlof, 1970) will not. The latter kind of costs is a result of the market transactions and not costs to undertake the transactions, such as making contracts or finding information about suppliers or customers.

What are then the economic incentives for firms to exchange information about process and product innovations, which they potentially may exploit on their own?

Distribution of Economic Incentives & Investments

Firms acquiring unique information may have an advantage of being able to exploit and take temporary monopoly control over potential innovations. Hippel (1988) argues, for instance, that innovations are initiated by firms expecting the most attractive innovation-related rents. The ability to utilize such information does not only depend on the ability to see the potential value of the information as such, but also to possess or acquire relevant knowledge and capabilities required for utilizing the information and to develop new processes and products. In economic terms, firms possessing required capabilities and recognizing potential rents from exploitation of the information may become innovators, while firms not possessing required capabilities or expecting high

costs in acquiring those capabilities will likely not become innovators. That is, the incentive to transfer potential rents, from exploiting an innovation, to another firm is expected to be higher among firms that are not able to exploit the innovation themselves, because of inappropriate capabilities or because of not recognizing the potential innovation-related rents per se. Further, unless a firm can change their role relative the potential innovation, for instance being a producer and becoming a user at a low cost and benefit from exploiting the innovation themselves (e.g. von Hippel, 1988), the transfer of information is likely to occur.

Further, if a firm recognizes the potential innovation-related rents but only possess a part of the capabilities required to fully exploit the information and to innovate, then it might be interested in diffusing the information to other firms. In economic terms, two answers may explain the diffusion of information and knowledge of secrets. First, it can be expected that firms share information as long as they expect to benefit from others acquiring the same information. That is, coordination of activities has to be done to obtain rents. Second, firms may experience higher rents if coordination with other firms is expected to leverage the benefits of the activities coordinated.

Here, the network provides an arena for the transfer and exchange of valuable information and trade secrets. The characteristics of network relationships discussed so far in this paper may also lead to lower costs concerning the transfer of secret information. For instance, von Hippel (1988) found, based on several case studies, that informal know-how trading is a characteristic of innovation strategies. He argues that informal know-how trading occurs when the knowledge, protected by keeping it secret only, exists and when the transaction costs of making a formal agreement are high in relation to the amount and quality of the information and knowledge to be exchanged or transferred.

The transfer of valuable information to other firms makes it possible for those firms to adopt an opportunistic behavior (Williamson, 1985). On a market with arm's length relationships, the risk for opportunism will certainly be high since firms may have neither obligations to each other nor risking any investments in relationships. In

networks, however, relation specific investments lower the risk of opportunistic behavior as long as the benefits for establishing a new relationship is higher than the costs for establishing it and the lost benefits of the investments made in existing relationships. Indeed, opportunism is a fundamental concept for the explanation of the existence of institutions, such as firms, contractual and trust relations (Foss & Koch, 1996). Here, it is important to stress the impact of the reputation effect (Telser, 1980), because opportunistic behavior in terms of a firm exploiting information itself might, in short-term, show higher profits than being honest to the firms in a network. However, since the firm has to establish new relationships with complementary activities, the negative reputation effect of previous behavior will certainly increase the costs. The inherent reputation effect in networks, thus leads to the expectation that firms investing in network relations are less likely less to adopt an opportunistic behavior than firms without any relation specific investment. Negative reputation effects lower the risk of revealing secret information (von Hippel, 1988).

The distribution of economic incentives in network is different from that on the market and in the firm. On the market, there is not distribution because of the risk of opportunistic behavior. The arm's length relationships do not include any commitment to fulfill obligations. Neither do firms invest in specific relationships and are thus not vulnerable for negative reputation effects due to opportunistic behavior. Of course, this is only true for large number markets. The firm, on the other hand, has a centralized agent, who makes contractual arrangements with input owners in a team productive process (Alchian & Demsetz, 1972). In comparison to the market, the firm makes, in this way, use of the input in a more efficient way than on the market since it "facilitates the payment of rewards in accord with productivity" (*ibid*., p. 778). This is turn, requires metering of input and metering of rewards.

A network does not have any centralized agent distributing economic incentives and rewards. The mechanism that distributes the economic incentives and rewards in networks is the individual assessment of potential rents by the possession of certain information and the ability and capability to exploit that information in coordination with other firms.

The stability of networks provides a fundamental uncertainty reduction not achieved by any other economic organizational form. The uncertainty and the risk of investing in particular activities, knowledge, capabilities, information etc. are reduced by the stability of long-term investments in network relationships. As long as the expected revenue from a team production in a network is positive and the potential loss of investments in existing network relationships is higher than the costs of investing in new relationships, the network will be stable. Further, the distribution of economic incentives to firms in a network, leads to lower risk of potential exits by the other firms and thereby loss of investments. The resulting organizational inertia of networks promotes complementary investments (Richardson, 1960/1990) between firms and the alignment of investment and production plans makes networks more efficient when coordinating complementary investments in economic activities.

We have now seen that close, long term relationships provides an arena for transfer and exchange of complex information that is relevant for firms of different roles in the product and process development. Suppliers, manufacturers, customers, and users understand the needs and wants of each other and decisions can be made based on more accurate information. Also, the distribution of economic incentives leading to a more stable network structure promotes complementary investments. A proposition may be stated as follows:

> Proposition:
> *Network relationships involve a higher degree of exchange of complex and relevant information compared to other types of market relationships.*

Expectations and decisions for future investments are crucial for the development of the competitive advantage for firms. The uncertainty of the future is, however, high and impossible to fully eliminate, no matter how much or accurate information that is acquired. As will be argued in the following chapter, the important characteristics of networks is to provide the basis for less uncertain information about the future and thereby making networks an alternative to other forms of economic organizations, such as gaining control and eliminating uncertainty through vertical integration (Richardson, 1960/1990).

The Creation of Future Markets

It has been argued that information about future needs are crucial for the development of successful innovations that allow firms to earn temporary monopoly rents. For instance, von Hippel (1986) stresses the need to identify "lead users". In comparison to users focusing on the present which are unlikely to develop needs that radically conflict with the present processes or products, "lead users" are firms that face future general needs, in terms of new products, processes, or services, before the majority of firms and which may benefit significantly from solving those needs. Although lead users may benefit to various degrees from new products or process or be as constrained to present technologies as other users, they are expected to be more familiar with future needs (Mansfield, 1968).

The problem of information about the future is that such market for information does not exist (Arrow, 1974a; Loasby, 1996). Two factors characterize the failure of future markets (Arrow, 1974a); first, the high cost of enforcing forward contracts, and second, neither of the parties, that is, the seller or the buyer, will probably make defined commitments about future actions because of the uncertainty. The cost of drafting and enforcing forward contracts is high because it is impossible to have complete information and perfect foresight (Alchian, 1950) of all potential events that might occur and their economical effects respectively. Even the market for insurances, which is build upon the uncertainty of the future, tend to lead to an adverse selection (e.g. Akerlof, 1970) to limit the number and risk of potential outcomes.

The willingness of the parties to ex ante define their future commitments when making a contract is depending on their expectations of the probabilities of the potential outcomes. Since information is dispersed and fragmented there will likely not be any agreement as to the probabilities of the future (Arrow, 1974a) since the parties have different information and different expectations. On a market with arm's length relationships according to the neoclassical assumptions, there will be no more information available than prices and quantities of present products and services being traded. Each firm knows only its production and needs (Arrow, 1974a, 1974b) and no

information is traded concerning quantities, prices, preferences, required technologies etc. about the future.

The non-existence of future markets may be divided into two main categories; the market of future goods and services, and the market of future technologies for the production. The uncertainty related to future technologies is not only linked to the type of radical innovations as referred to by Schumpeter (1934) but also the incremental improvements of existing technologies (Rosenberg, 1982). More specifically, Rosenberg (*ibid*.) stresses the crucial role of expectations, not only as to the future behavior of technological systems, but also the future rate of technological change. He argues that a central issue of the problem of expectations about future rate of improvements is the question of the sources of improvements. If improvements are a matter of learning-by-doing, then the pace of improvements is depending on the accumulation of experience and the period of time required to acquire the information. Expectations about a rapid rate of improvements may increase the risk of investing in a technology, which is to become obsolete in near future. An expected low rate of change, on the other hand, makes the risk of investing in short-life technology lower. Also, the expected rate of change will likely affect firms in their decisions how to adapt their activities to the technology.

However, Schumpeter (1934) emphasized that the discontinuous nature of innovations was not the outcome of a rational decision-making by the entrepreneur (Rosenberg, 1982; Loasby, 1996). Contrary to Schumpeter (1934), who argued that there could not be any rational decision-making by entrepreneurs, due to his view of a high risk and uncertainty in the innovation process, it is here argued that an increased level of rational decision-making is made possible by the shared expectation of firms in a network. These shared expectations are the result of mutual investments in relationships leading to a higher degree of stability in the network and thus a lower risk for investments in future commitments.

As long as there is uncertainty about the future there will be attempts to reduce risks (Arrow, 1974a). Of course, there is no possibility to completely eliminate the

uncertainty of the future in a complex economic system where decisions and actions are depending on the outcomes of a huge number of factors. Even though a network may limit the uncertainty as to the economic activities undertaken within that network, those activities will always be dependent on other parts of the economic system. The non-existence of future markets in one part of the economic system will "transfer" uncertainty to other parts, and that uncertainty may thereby destroy existing markets (Arrow, 1974a).

> *"A buyer will be unwilling to contract for purchase of a good if a superior or cheaper substitute may be available; and the seller will be unwilling to accept a price sufficiently low to be suitable to the buyer, particularly if he thereby precludes himself from a possible opportunity to shift his resources to other closely related goods.*" (Arrow, 1974a, p. 9)

Market relationships do not provide any mechanism for reducing the uncertainty. Networks, on the other hand, may be a way of partially reducing the uncertainty of the future. The uncertainty may be reduced to a level where a more limited number of potential scenarios are expected to occur. Future plans made by a firm, with only arm's length relationships with other firms, will depend on the firm's decisions and actions without any coordination with other firms on the market.

Plans made by firms in a network, which are based on expectations of the same of events, will be executed based on initially decided common expectations. Although these plans are determined upon independently and perhaps are not fully coherent due to variations in interpretations of information, they are still compatible. Since decisions are made based on common set of expectations it means that relationships in networks limit the number of potential outcomes of activities undertaken in the network. Also, decisions are made based on coherent expectations about the future and complementary future plans. Thus, the set of probabilities of certain future outcomes as expected by each individual firm in a network become higher and thus more certain than expected probabilities of outcomes from coordination through market relationships. Although it

will not eliminate uncertainty completely, the expected probabilities are likely to increase and thereby creating a less uncertain future market for each firm in the network. May it be concerning the future needs of customers and users, or the future technologies provided by suppliers.

The reduction of uncertainty does not come without a cost. Obviously, if information about the future were perfect, no risk and thus no losses or gains would exist as a result of decisions and actions taken by firms. Routines may become an obstacle in recognizing the opportunities for new complementary combinations and thus innovation (Loasby, 1996). Also, the obsolescence of other firms' technologies may seriously affect the competitive advantage of the network (Afuah, 2000). Also, information from other firms in the network, a rather limited selection of firms compared to the total number of firms in many industries, might be more biased than the average would be. Further, firms concerned about the present may be biased towards problem solving in the existing technologies, which of course is most familiar to them. There is consequently a risk that ideas for innovations are focused on existing problems and not future possibilities (von Hippel, 1986).

Empirical Test

The data used for testing the hypothesis is obtained from a survey of inter-firm relationships made in 1995 by Statistics Denmark in co-operation with Eurostat. The purpose was to analyze subcontracting relationships in the manufacturing sectors. The questionnaire was distributed to 4065 firms belonging to the population of manufacturing firms according to NACE[3] classification 15 to 36. The population was further limited to firms with 10 or more employees in 1994. 1278 firms responded, resulting in a response rate of 31,4 percent. The response analysis indicated a large variation in the data material, although the response rate varied in different sectors. Lowest response rates were found in sectors 16 (16,7%) and 19 (13,0%), and 26 (24,8%) while highest response rates were found in sectors 25 (37,2%), 30 (50,0%), and 31 (36,2%). No response rate was found in sector 23 (0%).

Each firm was asked to submit information about the four most important suppliers and customers respectively, in terms of profit. For each relationship, the firms had to answer 19 questions, based on dichotomous answers. The data contains in total 5009 relationships. 167 relationships have been discarded due to inadequate answers, resulting in a total of 4842 relationships for the analysis. The distribution of relationships in different sectors according to the NACE classification is shown in table 1.

[3] NACE Rev. 1

Table 1: Distribution of relationships on NACE sectors.

NACE (Rev. 1)	Branch	No of relation-ships	Share of relation-ships (%)
15-16	Manufacture of food products, beverages and tobacco	320	6,6
17-18	Manufacture of textiles and textile products	381	7,9
19	Manufacture of leather and leather products	18	0,4
20	Manufacture of wood and wood products	235	4,9
21-22	Manufacture of pulp, paper and paper products; publishing and printing	452	9,3
23	Manufacture of coke, refined petroleum products and nuclear fuel	0	0
24	Manufacture of chemicals, chemical products and man-made fibres	127	2,6
25	Manufacture of rubber and plastic products	343	7,1
26	Manufacture of other non-metallic mineral products	156	3,2
27-28	Manufacture of basic metals and fabricated metal products	799	16,5
29	Manufacture of machinery and equipment n.e.c	818	16,9
30-33	Manufacture of electrical and optical equipment	651	13,4
34-35	Manufacture of transport equipment	165	3,4
36	Manufacturing n.e.c.	377	7,8
	Total	**4842**	**100**

The relationships have been divided in different categories based on the answers given by the firms to five selected questions. The questions, shown in table 2, are used as a proxy for measuring the type of market relationship, ranging from an arm's length market relationships to a network relationship, based on the definition of network relationships in this paper. The answers given by the firms reveal the characteristics of their inter-firm relationships in terms of intended long-term collaboration and relation specific investments in sunk costs, thus, making a comparison between different types of relationships possible by analyzing the combination of the answers.

Each question can be answered by a "yes" or a "no". A "yes" is given the value of "1", and a "no" is given the value of "0". The total value for each relationship, between the respondent firm and one of its suppliers or customers, is reached by the sum of the answers given to the questions in table 2. Consequently, a relationship can be given the

minimum value of "0" and the maximum value of "6", thus, resulting in a set of seven categories ranging from "0" to "6". The number of relationships obtaining the value of "6" was low (in total 17 relationships) and relationships with the total value of "5" and "6" are grouped in category "5". With reference to the definition of market relationships in the paper, an inter-firm relationship with a total value of "0" is considered an arm's length relationships on the market, while an inter-firm relationship with a total value of "5" (or "6") is considered to be a network relationship.

Firms have been asked to provide information about their relationships with both suppliers and customers. It is important to note that information about each relationship is given by only one of the firms in the dyads.

Table 2: Questions for categorizing inter-firm relationships

Questions to firms in their role as customers
1. Does your firm frequently resell goods produced by the supplier under your trademark?
2. Does your firm occasionally make tools, buildings, or expertise available for the supplier?
3. Does the supplier occasionally make tools, buildings, or expertise available for your firm?
4. Have your firm and the supplier made an agreement about profit sharing?
5. Have your firm and the supplier adjusted item numbers to each other?
6. Does it exist certain contracts, documents, declarations of intent etc. beyond normal orders?

Questions to firms in their role as suppliers
1. Does the customer frequently resell goods produced by your firm under his trademark?
2. Does the customer occasionally make tools, buildings, or expertise available for your firm?
3. Does your firm occasionally make tools, buildings, or expertise available for the customer?
4. Have your firm and the customer made an agreement about profit sharing?
5. Have your firm and the customer adjusted item numbers to each other?
6. Does it exist certain contracts, documents, declarations of intent etc. beyond normal orders?

For each of the six categories of relationships ("0" to "5"), the characteristics of the information exchange in terms of complex and relevant information have been analyzed. Here, four other questions, shown in table 3, were used. The presence of product development is used as a proxy for complex information exchange, here

represented by the answers to questions 1 and 2. If none of the firms in a dyad are undertaking relation specific product development activities, the information exchange is categorized as "low complexity". On the other hand, if one of the firms or both of them are undertaking relation-specific product development activities, the information exchange is categorized as "high complexity (1)" or "high complexity (2)" respectively.

Further, the presence of information exchange concerning the alignment of future production plans and future product ideas are taken as proxies for the exchange of relevant information, here represented by the answers to questions 3 and 4. If no exchange of information concerning production plans or new product ideas occurs in the relationships, the information exchange is categorized as "no exchange". If either exchange of production plans or exchange of new product ideas occurs in a relationship, the information exchange is categorized as "exchange (1)", while exchange of both production plans and new products ideas is categorized as "exchange (2)".

Table 3: Questions for categorizing information exchange in relationships

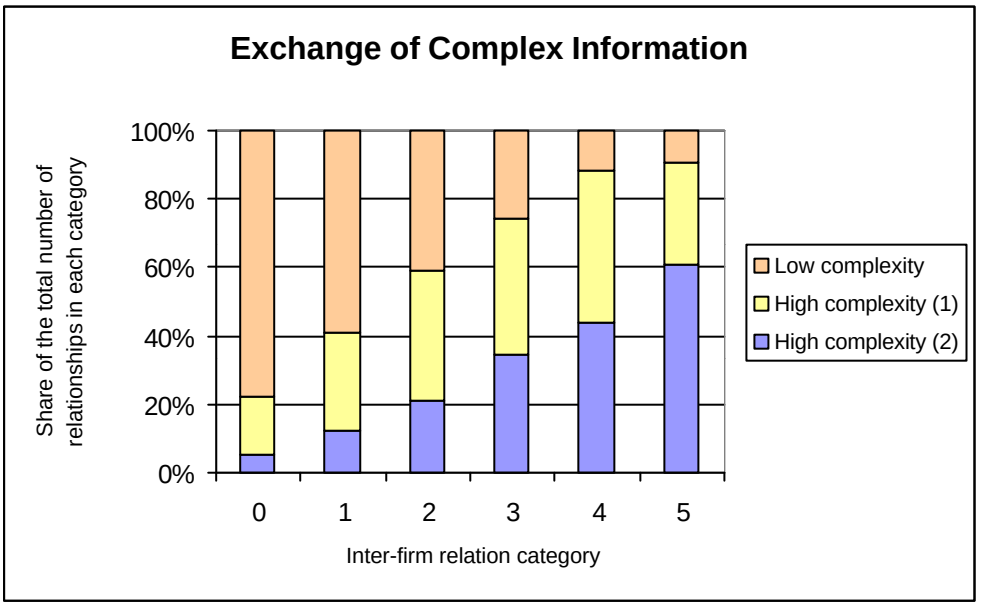
Questions to firms in their role as customers
1. Does your firm actively cooperate in developing the products of the supplier?
2. Does the supplier actively cooperate in developing the products of your firm?
3. Does your firm regularly exchange production plans with the supplier?
4. Does your firm regularly exchange ideas concerning new products with the supplier?

Questions to firms in their role as suppliers
1. Does your firm actively cooperate in developing the products of the customer?
2. Does the customer actively cooperate in developing the products of your firm?
3. Does the customer regularly exchange production plans with your firm?
4. Does the customer regularly exchange ideas concerning new products with your firm?

Findings

An expected increase of the exchange of complex and relevant information in network relationships compared with other types of market relationships is confirmed by the patterns of information exchange in the inter-firm relationships as categorized in this paper. That is, low complexity information and non-relevant information exchange is more common in category "0" relationships (here labeled as arm's length relationships), and complex and relevant information exchange are more common in category "5" relationships (here labeled network relationships).

Figure 1: Exchange of complex information



The share of relationships with low complexity information exchange is highest in inter-firm relationship category "0", 77,5% (see table 4). The share is decreasing as the number of the relationship category increases. The smallest share is found in relationship category "5", 9,5%. Conversely, the share of relationships with high complexity information exchange increases from 5,5% to 60,7%, regarding "High complexity (2)" where both firms were undertaking relation specific product development activities. The total share of relationships with high complexity information exchange ("High complexity (1)" + "High complexity (2)") increases from 22,5% to 90,5%. This means that arm's length market relationships, that is inter-firm

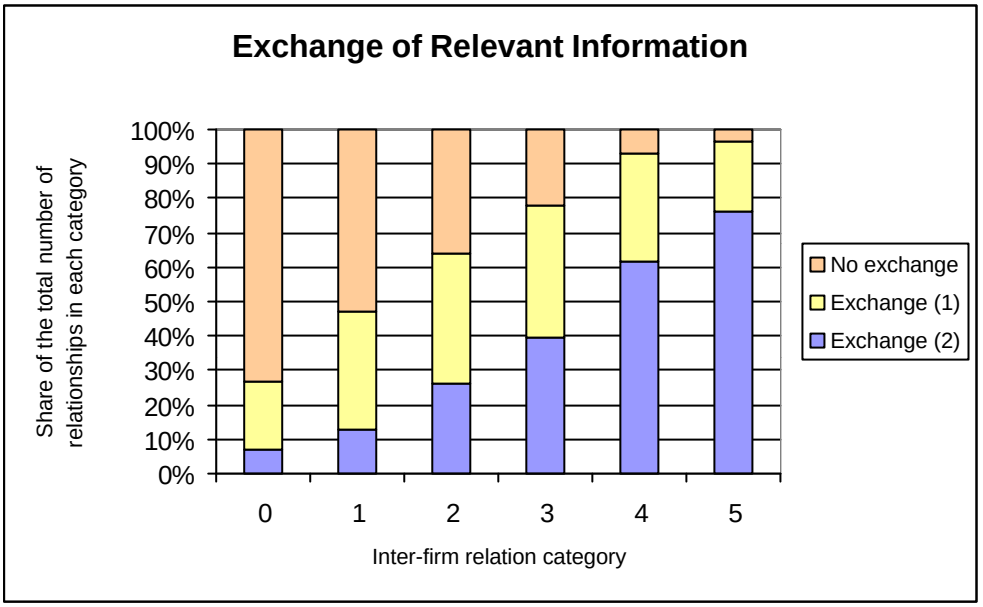
relation category “0”, contain a higher degree of low complexity information exchange than network relationships (inter-firm relation category “5”). Thus, the proposition is confirmed concerning the complexity of information exchange in inter-firm relationships.

Table 4: Exchange of complex information

Inter-firm relationship category	Total number of relationships	No of relationships with low complexity information exchange	Share of relationships in the relationship category (%)	No of relationships with high complexity information exchange (1)	Share of relationships in the relationship category (%)	No of relationships with high complexity information exchange (2)	Share of relationships in the relationship category (%)
0	1642	1273	77,5	279	17,0	90	5,5
1	1386	821	59,2	395	28,5	170	12,3
2	1018	415	40,8	390	38,3	213	20,9
3	509	130	25,5	202	39,7	177	34,8
4	203	24	11,8	90	44,3	89	43,9
5	84	8	9,5	25	29,8	51	60,7
	4842	2671		1381		790	

Regarding the exchange of relevant information in inter-firm relationships, the result is shown in figure 2.

Figure 2: Exchange of relevant information



The share of relationships with no exchange of relevant information is highest in inter-firm relationship category "0", 73,4% (see table 5). The share is decreasing as the number of the relationship category increases. The smallest share is found in relationship category "5", 3,6%. Conversely, the share of relationships with high level of exchange of relevant information increases from 6,8% to 76,2%, regarding "Exchange (2)" where both production plans and new product ideas are exchanged in the relationship. The total share of relationships with high level of exchange of relevant information ("Exchange (1)" + "Exchange (2)") increases from 26,6% to 86,4%. This means that network relationships (inter-firm relation category "5") contain a higher degree of exchange of relevant information than arm's length market relationships, (inter-firm relation category "0"). Thus, the proposition is confirmed concerning the exchange of relevant information in inter-firm relationships.

Table 5: Exchange of relevant information

Inter-firm relationship category	Total number of relationships	No of relationships with no relevant information exchange	Share of relationships in the relationship category (%)	No of relationships with relevant information exchange (1)	Share of relationships in the relationship category (%)	No of relationships with relevant information exchange (2)	Share of relationships in the relationship category (%)
0	1642	1205	73,4	325	19,8	112	6,8
1	1386	734	53,0	472	34,0	180	13,0
2	1018	369	36,3	384	37,7	265	26,0
3	509	112	22,0	195	38,3	202	39,7
4	203	14	6,9	64	31,5	125	61,6
5	84	3	3,6	17	20,2	64	76,2
	4842	2437		1457		948	

Conclusions

The network, as a form of economic organization, exists to combine information and knowledge required to solve complex technological problems, such as development of new products or processes. A network does not only provide an arena for more efficient information handling between firms, but each firm in a network also function as a specialized information handling entity for information from external sources, thus providing a variety of different information and knowledge channels into the network. Close inter-firm relationships enable transfer and exchange of relevant and complex information. Not only manufacturers are innovators but also suppliers, customers, and users. Information acquired by other firms involved in the production or usage of a certain product or service may be of value for adjusting, enhancing and developing new products and services. Also, long-term relationships generate a code of information exchange that enables transfer and exchange of relevant information. Although more information than is needed sometimes has to be transferred, the information handling by specialized firms select the relevant information, which has to be transferred. Consequently, acquiring and transferring information between closely connected firms on a long term basis will be less costly and more efficient than, for instance, arm's length market relationships. Costs associated to the search, evaluation and the uncertainty of information acquired on the market are higher than the costs of acquiring information through network relationships. Moreover, the reputation effect inherent in network relations makes network information channels more reliable than other sources.

Innovations are initiated not only by producers but can be sourced from several other kinds of firms. It is expected that the firms assessing the highest potential innovation-related rents are most likely to initiate innovation. Thus, the source of innovation will differ from industry to industry and from firm to firm. Networks, as has been argued, create the possibility to transfer and exchange complex information about existing products, processes, and services, and in addition future needs and technological possibilities. This exchange of information is crucial for innovations. Further, the distribution of economic incentives among firms make network relationships stable and the cost of short-term opportunism in terms of a negative reputation effect becomes much higher than the long-term benefits being linked to a network. The information

exchange and distribution of economic incentives based on stable relationships enables firms to align plans about product and process developments and the routine based production at a lower risk. Moreover, the alignment of plans and coordination of investments are made under the influence of a lower uncertainty than what would prevail in the market of arm's length relationships. The reduction of uncertainty of investments the creation of future markets is one of the most important features of networks.

The proposition presented in this paper seems to be confirmed by the empirical findings of information exchange in different types of inter-firm relationships. The conclusion that can be made on the basis of the analysis is that networks are the preferred organizational form when coordinating complementary economic activities involving complex information exchange. Also, the degree of relevant information exchange is high and, thus, promoting the economics of information exchange in networks compared to other types of market relationships.

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