2 Industrial Networks of the Future: Review of Research and Practice

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Abstract Academic researchers have followed closely the interest of companies in establishing industrial networks by studying aspects such as social interaction and contractual relationships. But what patterns underlie the emergence of industrial networks and what support should research provide for practitioners? Firstly, it appears that manufacturing is becoming a commodity rather than a unique capability, which accounts especially for low-technology approaches in downstream parts of the network, for example in assembly operations. Secondly, the increased tendency towards specialization has forced other, upstream, parts of industrial networks to introduce advanced manufacturing technologies to supply niche markets. Thirdly, the capital market for investments in capacity, and the trade in manufacturing as a commodity, dominates resource allocation to a larger extent than previously was the case. Fourthly, there is a continuous move towards more loosely connected entities that comprise manufacturing networks. More traditional concepts, such as the "keiretsu" and "chaibol" networks of some Asian economies, do not sufficiently support the demands now being placed on networks. Research should address these four fundamental challenges to prepare for the industrial networks of 2020 and beyond.

Keywords Agile manufacturing, Core competencies, Global operations, International issues, Keiretsu networks, Manufacturing strategy, Outsourcing

2.1 Introduction

In recent years, practitioners and researchers have started to look increasingly at companies as part of networks within which they operate. This is often because of the possibilities offered by information technology and data-communication, globalization of markets and the increasing tendency of companies to specialize (e.g. Karlsson, 2003). These possibilities give firms easier access to the capabilities and resources of others, moving them further away from the traditional logic behind the make-or-buy decision; even though this particular manufacturing decision still attracts attention from researchers to develop appropriate models (e.g. Cáñez *et al.*, 2000; Humphreys *et al.*, 2002; Probert, 1997). Additionally, the world of management has seen an abundance of theories that might have been adequate to deal with the contemporary challenges for some enterprises, but not for many others

(Fischer and Hafen, 1997; Micklethwait and Wooldridge, 1996). The notion of core competencies and the concept of Lean Production serve as examples of such theories that address questions relating to Supply Chain Management in the context of industrial networks; but it could be questioned whether they really deal with the characteristics of networked organizations. Capello (1996, p. 496) supports this statement by noting that insufficient is known about the failing of networks. In this chapter, the authors argue that industrial networks require the adaptation of existing theories to fit their particular characteristics as wells as the development of grounded theories based on the unique characteristics of industrial collaboration.

2.1.1 Brief History of Industrial Networks

Although the study of industrial networks has attracted recent attention among researchers, there was already an awareness of the implications caused by the

Table 2.1. *Evolution of organizational forms (Miles and Snow, 1984, p. 19). The table indicates the evolution of organizational forms that are both internally and externally consistent. Miles and Snow state in their paper that a minimal fit is necessary for survival, a tight fit associates with corporate excellence, and an early fit provides a competitive advantage. Therefore, dynamic networks (industrial networks) require both internal fits and external fits, giving early adopters a competitive advantage.*

Period	Product-market strategy	Structure	Inventor or early user	Core activity and control mechanisms
1800 -	Single product or service. Local/ regional markets.	Agency	Numerous small owner-managed firms.	Personal direction and control.
1850 -	Limited, standardized product or service line. Regional/ national markets.	Functional	Carnegie Steel.	Central plan and budgets.
1900 -	Diversified, changing product or service line. National/ international markets.	Divisional	General Motors, Sears, Roebuck, Hewlett-Packard.	Corporate policies and division profit centres.
1950 -	Standard and innovative products or services. Stable and changing markets.	Matrix	Several aerospace and electronic firms.	Temporary teams and lateral resource allocation devices such as internal markets, joint planning systems, etc.
2000 -	Product or service design. Global, changing markets.	Dynamic network	International/ construction firms. Global consumer goods companies. Selected electronic and computer firms (e.g. IBM).	Broker-assembled temporary structures with shared information systems as basis for trust and co-ordination.

particular characteristics of networked organizations (Håkansson and Johanson, 1988; Wiendahl and Lutz, 2002). In particular, academic interest has centred on two periods in the past. The first of these was during the 1970s and 1980s when attention was focused on Japanese manufacturing concepts and techniques, including Just-In-Time (JIT), co-production and "keiretsu" networks. The second period started during the 1990s, after the bursting of Japan's "bubble" economy, as a consequence of the drive for even lower cost, greater efficiency, and responsiveness to customer demands. This resulted in a more formal recognition of the networked organization as a follow-up to the paradigm of core competencies and the consequent escalation in outsourcing. The earlier overview by Miles and Snow (1984) illustrated the move from the simpler paradigms to more complicated forms of network-based organizations that have subsequently been witnessed in recent years (see Table 2.1) and consequently have attracted academic deliberation.

The establishment and emergence of industrial networks is closely related to the subject of manufacturing strategy. Since Skinner's seminal work in this area (Skinner, 1969), manufacturing has been recognized as a fundamental cornerstone for achieving corporate competitive advantage. Although it recognises the traditional and limited perspective of considering low cost and high efficiency as dominant objectives within manufacturing strategy, this earlier work of Skinner is still rooted in the tradition that economies of scale provide competitive opportunities (Penrose, 1963, pp. 260–265). That tradition has given rise to the monolithic company driven by forward and backward integration (Chandler, 1977), which implied an emphasis on the coordination of operations. Only later does Skinner consider the role of smaller-scale units that may now be regarded as elements of an industrial network (Skinner, 1974), while subsequently questioning the traditional efforts towards productivity improvement through making large capital investments in manufacturing (Skinner, 1986). According to Sturgeon (2002, pp. 8–10), American firms – compared with most Asian and many European companies – have generally placed manufacturing in a low position on the hierarchy of corporate esteem. However, in contrast to Sturgeon's belief, it is argued here that this is also the case for European firms. For example, most companies still regard efficiency as the main objective of their production departments in a survey amongst Spanish companies (Avella, 1999). Consequently, during the 1960s and 1970s the make-or-buy decision was at the heart of Operations Management research. Then, in the 1980s, the interest in Japanese manufacturing techniques, including partnerships with suppliers, sparked the next step towards models for collaboration and Supply Chain Management using JIT principles, while in the early 1990s the concept of core competencies led to renewed interest in outsourcing models. Later the "over-the-wall" tactics of outsourcing made companies examine the networks they had created while managing these from a traditional cost perspective (Dekkers *et al.*, 2002). In the end, the increasing attention paid to networks has not challenged the proposition of Skinner that manufacturing is of paramount importance to industrial performance; and it has not altered that the most common view of manufacturing (including manufacturing networks) is taken from the traditional cost perspective.

2.1.2 The Impact of Globalization

The awareness that has been created that manufacturing strategy comprises more than cost-driven objectives, e.g. meeting customer demands, has created a wider array of perspectives for manufacturing; these perspectives on manufacturing strategy, complemented by the influence of advances in information and communication technology together with globalization and specialization, foster the specific characteristics of industrial networks, i.e. collaboration, decentralization and inter-organizational integration (O'Neill and Sackett, 1994). In these three fields each change in itself requires adaptations by companies and the influence of several of these shifts leverage the need for adequate responses. For example, collaboration requires not only solutions in advanced software, it should also account for the management of industrial networks in an international context whereby individual companies set their own course and develop over time (decentralization). Conversely, efficient international collaboration depends on the appropriate deployment of information and communication technology. The intricate interdependencies of these characteristics transform industrial networks into collaborative efforts that have a large number and wide variety of resources at their disposal especially to meet a greater range of customer demands.

This has caused a change in the prevailing attitude towards resource allocation due to the emergence of the industrial network paradigm. The need for proximity of supply, following the theories about co-production, has required a strong interaction between customers and suppliers. Consequently much research has focused on the need for economic clusters (e.g. Porter, 1990). There are examples of these tendencies changing, like Daimler Chrysler's announcement in 2000 that suppliers need to deliver in six days (rather than 1–2 days previously, with close geographical proximity). It illustrates the different views towards supplier selection and purchasing management that are emerging now; the different views enable to the supplier base to be considered as a network rather than a set of individual actors.

Not only has the scene for suppliers to any industry changed, but many more countries have also followed an active path towards developing relevant economic and industrial competencies, reinforcing the establishment of supply networks. For example, the Thai government has deliberately set out to strengthen its automotive sector by attracting foreign companies in that industry (Katayama, 1999). By contrast, during the 1990s, MIT undertook a study that led to a warning about the decline of manufacturing industry in the U.S.A. (Lester, 2003). However, more recently the U.S.A. has adopted a more progressive approach with the study on Visionary Manufacturing Challenges (NRC, 1998), the U.K. government stimulated the creation of Innovative Manufacturing Research Centres (Dekkers and Wood, 2007) and for the first time the Dutch government set out a research strategy to support the manufacturing industry (de Vaan *et al.*, 2002). Consequently a complex pattern has emerged with the industrial base undergoing shifts by moving to developing countries, emerging countries entering the manufacturing arena, and a revival of some traditional industrialized countries, thus making the situation more dynamic than ever before; in the end, these national policies have only encouraged more extended industrial networks.

At the same time, the make-up of industrial networks has undergone changes, too. The external drivers (such as the move from make-or-buy to co-production or alliances and the drive for flexibility of manufacturing) as well as the internally oriented concepts (such as the attempts to apply Computer Integrated Manufacturing and the use of production cells) demonstrate a continuous move towards more loosely connected industrial entities for manufacturing. The requirement for greater flexibility also impacts on the trend to increase the amount of customization and production of goods on-demand (Lee and Lau, 1999). Contemporary changes in industries point to a further repositioning along the dimension of loosely connected entities, with increasing pressure to respond to market opportunities and to increase flexibility.

2.1.3 Scope of Chapter

Following the moves made by companies as identified previously, this chapter explores the concept of industrial networks for manufacturing. It aims to visualize an approach for industrial networks of the future, i.e. for the next 15 years and beyond, based on ongoing research and additional considerations. Firms are operating increasingly as parts of industrial networks, although the situation is extremely fluid and the stage has not yet been reached where networks are configured optimally and network operations have reached a stage of maturity. Consequently, the chapter also aims at contributing to the research agenda and making a contribution to foundations for generating grounded theory about industrial networks.

Initially, in Section 2.2, this chapter examines the types of traditional networks that have been identified, together with the reasons for which they have been formed and their advantages and weaknesses. This includes a critique of the traditional “keiretsu” and “chaibol” networks based on conglomerate structures that formed the basis of Japan’s and Korea’s economic success. In Section 2.3, this chapter addresses how future networks will be shaped by discussing three contributory and related topics: network configuration, manufacturing as commodity and added value within networks. The chapter then moves to present the outlines of a research agenda in Section 2.4. This contribution to directing research into industrial networks uses a blend of illustrations (from the business literature), findings of previous studies by others together with results from research by the authors, to construct a picture of how future networks might look and behave.

2.2 Traditional Views About Networks

The study of networks as a key aspect of industrial organization goes back to the 1980s with the seminal work of Håkansson at Uppsala University, who defined networks as sets of more or less specialized, interdependent actors involved in exchange processes (Håkansson and Johanson, 1988, 1992). Around the same time the study of urban, networked organizations in the industrialized regions of northern Italy recognized the importance of networks for improving logistical efficiency (Camagni, 1988, 1993). The participation of companies in these networks depends on managing product development, both at the level of the network and the individual companies, and on managing manufacturing processes. Within the overall primary process of most companies the connection between product development and manufacturing strategy has yet to result in conceptual approaches to establish this vital link. Conducting a study into sequential and simultaneous approaches to engineering new products, Riedel and Pawar (1998) highlight that the concepts of design and manufacturing are not linked in the literature and that the interaction of product design and manufacturing strategy is under-researched. Spring and Dalrymple (2000) came to a similar conclusion when examining two cases of product customization, where manufacturing issues received little attention during design and engineering. The only concept that addresses these issues so far is the one of the Order Entry Points (more commonly known as Order Decoupling Points; see Figure 2.1). Order Entry Points and modular product architecture typically concern the optimization of Make-to-Order production concepts and might include product development and engineering activities (Dekkers, 2006a). Introducing a different perspective, Smulder *et al.* (2002) proposed a typology of intra-firm and inter-firm interfaces, therewith also connecting product development and production; yet, this typology has still to be adopted in practice. Henceforth, the emerging paradigm of industrial networks, if it is to be successful, should address this matter of creating a link between manufacturing strategy and product development.

But do we find this link in current concepts for industrial networks? Three mainstream Operations Management concepts in this area dominate thinking about the industrial network paradigm: core competencies, agile manufacturing, and "keiretsu" and "chaibol" arrangements. As shown in the next three subsections, these concepts focus mainly on issues of manufacturing and less on product development, except in general terms.

2.2.1 Core Competencies and Outsourcing

According to Friedrich (2000), focusing on core competencies (Prahalad and Hamel, 1990) and outsourcing (Gilley and Rasheed, 2000) raises the key issue of which areas of production are needed to maintain the value chain and on which areas the company should concentrate for achieving optimal performance. Prahalad and Hamel subtly expand the view of technology from a broadly described concept, the importance of which is determined by its support of the corporate mission, to a specific source of corporate uniqueness. In Prahalad and Hamel's view core competencies represent the collective learning of the organization, especially concerning how to coordinate diverse production skills and integrate multiple streams of technology. However, the application of this theory does not lead directly to a clearly defined strategy for global manufacturing or manufacturing networks. Only when core competencies are linked to decision-making will a manufacturing strategy be found that offers guidelines on decision-making for resource acquisition and capacity management (Hayes and Pisano, 1994).

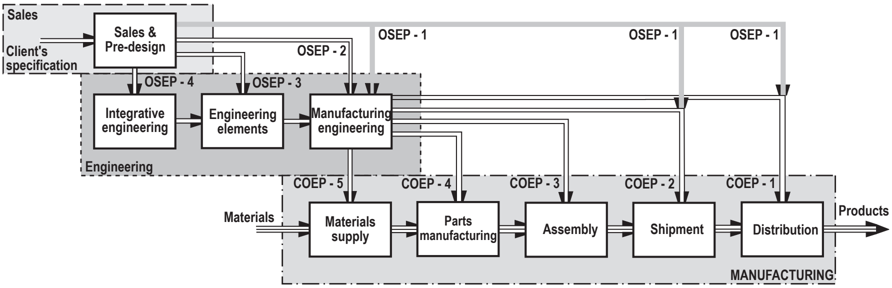

Figure 2.1. *Position of the Order Entry Points in the primary process of design, engineering, manufacturing and logistics. To simplify the figure, points of stock (inventory) have been omitted. OSEP-1 (Order Specification Entry Point) indicates that customer requirements are directly transferred into production instructions, while OSEP-4 points to Engineering-to-Order. Similarly in the material flow: COEP-1 (Customer Order Entry Point) tells that orders are delivered directly from stock, while COEP-5 marks Make-to-Order.*

Given the (often unquestioned) popularity of the concept of core competencies and its implications, how does industry manage the increasing scope of outsourcing? A study by Dekkers (2005a) based on 6 case studies (four in the Netherlands, one in China and one in Indonesia) points to poor control of outsourcing by industrial companies. Most of the case companies, with primary processes based mainly on Engineering-to-Order and Make-to-Order, experienced problems with implementing manufacturing strategies. Ideally, the manufacturing strategy of these companies should address their core competencies and opportunities for outsourcing. All the case companies, except one, had done so, implicitly or explicitly; but mostly this strategy had not been transferred to guidelines for implementation, which is why decision-making occurred at random or through opportunity. There was no feedback about suppliers' performance to the stages of design and engineering, so sometimes problems would recur regularly. None of the companies followed an active approach towards supplier networks for the purpose of expanding their technological capabilities. Operational control posed additional challenges, although not all companies were aware of the impact this caused. In two cases the in-house production of some manufacturing processes proved more beneficial than outsourcing, although this was only discovered with hindsight. All the companies reported problems with on-time deliveries by suppliers, with some of these problems arising from reactive interventions rather than pro-active securing of purchase orders. In summarizing these case results, it can be concluded that operational control in these companies created a wide variety of problems. That is evidenced by poor operational control and poor integration between design, engineering, purchasing and manufacturing; additionally, it indicates that the simplified view of core competencies and outsourcing might have strong limitations.

Still today, even though insight into effective manufacturing strategies has progressed, many approaches for outsourcing rely on the deployment of criteria derived from traditional make-or-buy decisions. However, the rise of industrial networks creates the need for frameworks that take account of early supplier involvement, collaboration, and inter-organizational integration. Also, decision-making concerning the allocation of resources has shifted from making one-time decisions to continuous evaluation and reallocation. Current outsourcing approaches rarely account for this, and, hence there is a need for expansion of criteria to include those suitable for networks. Current practices for management and control of outsourcing still focus largely on minimizing costs and meeting delivery schedules, while research into outsourcing has not yet investigated the specific impact of industrial networks (Dekkers *et al.*, 2002).

2.2.2 Agile Manufacturing Networks

In contrast to the concept of outsourcing, the approach of agile manufacturing relies more strongly on the exploitation of loosely connected networks than earlier concepts such as Lean Production (Nagel *et al.*, 1991; Burgess, 1994; Katayama and Bennett, 1999). Co-production (and subsequently Lean Production) had already introduced a higher degree of outsourcing and improved control through Supply Chain Management, although here the networks used were more closely connected keiretsu or chaibol types involving cross-ownership, as described later. In contrast to the internal focus of Lean Production, the paradigm of agile manufacturing has an external focus and is primarily concerned with the ability of enterprises to cope with unexpected changes, to survive against unprecedented threats from the business environment, and to take advantage of changes as opportunities (Goldman *et al.*, 1995). Similarly, Kidd (1995) recognizes two main factors within the concept of agility, i.e. responding to changes in appropriate ways and in due time, and taking advantage of the opportunities resulting from change. This means that an agile manufacturing enterprise marshals the best possible resources to provide innovative (and often customized) products, with the flexibility to adjust the product and offer rapid delivery, and with the high level of efficiency required to be competitive and profitable (Goldman and Nagel, 1993, p. 19). The concept of agile manufacturing stresses two interconnected main processes:

i) the development of innovative products;
ii) the manufacturing and distribution of products.

These two processes should meet lead-time requirements (time-to-market, time-to-volume and delivery time) and flexibility requirements (to meet market opportunities and respond to market demands) (Stock *et al.*, 1999). A reconfigurable structure becomes a prerequisite for optimizing the capabilities of an organization for each business opportunity (Ross, 1994), which itself requires more loosely connected entities.

However, even the new types of agile manufacturing networks are often not designed within an international context and may still be suboptimal where acquisitions have taken place resulting in an inherited supplier base. Therefore, the notion of building international manufacturing networks is now a prevalent concern where competitiveness derives from an ability to garner and integrate resources from a number of different geographical sources. The basic principles for building a manufacturing network have been described by Mraz (1997), who identifies four categories of resources (i.e. players) that can be used within the network: industrial design consultants, product development consultants, contract manufacturers, and Original Equipment Manufacturers (OEMs). These last two players also demonstrate the options available for the production of complex products and their relative advantages and disadvantages, with the contract manufacturing approach typically involving external industrial design and product development, and the OEM approach typically retaining these activities in-house. A hybrid of these two forms can be found in the case of the Brazilian aircraft manufacturer Embraer (Empresa Brasiliera de Aeronáutica SA), which, with its network of risk sharing partners, was able to greatly accelerate the development and launch of the ERJ-170/190 series of regional jets. Hence, adequate suppliers' bases, with possibly an international dimension, reinforce the performance during product development (reduced time-to-market) and manufacturing (improved performance to deliver) to the advantage of OEMs and their supplier networks.

The international dimension to designing agile manufacturing networks is also considered by Lee and Lau (1999), who use the example of firms in Hong Kong and the Pearl River Delta to provide a "Factory-on-Demand"-concept within the context of manufacturing networks. Shi and Gregory (1998) have contributed by proposing the mapping of configurations for international manufacturing networks as a means of providing support for decision-making. Presentations by companies at the *9th Annual Cambridge International Manufacturing Symposium* in 2004, organized by the University of Cambridge, have shown that there are two strategic directions for international manufacturing networks: "rationalization" (with manufacturing units, sometimes including product development, specializing on product ranges) and "globalization" (taking the opportunity to outsource operations or establish alliances). As frequently evidenced in the literature (e.g. Shi, 2003), the current drive for globalization by companies places its emphasis more on optimization within existing conditions and less on capturing new market opportunities, even for the opportunities these international manufacturing networks offer.

2.2.3 Keiretsu and Chaibol Networks

Unlike the networks of Western companies, the "keiretsu" and "chaibol" networks that formed the basis of Japan's and Korea's economic success were based on conglomerate structures. However, more recently these structures have proved less capable of meeting the need for speed of change, flexibility, and cost reduction that have been the key aspects of industrial management following the Asian economic crisis of the late 1990s (Business Week, 1999). At the same time, organizations that attempted to replicate the keiretsu concept outside Japan have encountered severe problems, making them rethink their plans to create similar supply networks (Stein, 2002).

A major weakness of the traditional keiretsu and chaibol networks has been their domestic focus and cross-ownership between companies in the network. This has hindered how they can respond effectively to the globalization of manufacturing (Bennett, 2002). It has also created difficulties as end-product manufacturers have moved offshore and taken them beyond the reach of domestically based network members. Also, the burden of debt resulting from borrowing to support cross-ownership has restricted their ability to develop and fully support international operations. As a consequence of this situation Renault, on taking a controlling interest in Nissan, sought to dismantle its keiretsu supplier network by selling off most of its financial stakes in almost 1,400 companies (Zachary, 2001). This indicates that companies deploying traditional networks are searching for different concepts to manage their suppliers.

However, despite these concerns, a study by McGuire and Dow (2003) still shows that throughout the first half of the 1990s the keiretsu system remained strongly in place. At the same time, they conclude that the continued move toward globalization of capital markets in Japan and ongoing regulatory change may potentially impact networking and performance implications. Apart from the problems that can arise when there is cross-ownership between companies, the main criticism of the keiretsu relates to its lack of flexibility and responsiveness. The answer to this criticism has therefore been to propose the creation of agile networks (Tian *et al.*, 2002).

2.2.4 Traditional Views on the Wane

Despite the theoretical ability of agile manufacturing to provide greater flexibility and responsiveness there are still questions about whether it can address the characteristics of networks, i.e. decentralization of decision-making, inter-organizational integration and collaboration. The Special Issue on Dispersed Manufacturing Networks underlines the fact that progress is being made slowly (Dekkers, 2006b). The questions around the paradigm for networks that consist of loosely connected entities only demonstrate that we still know little about their behaviour. Nevertheless, many developments in information technology and data-communication allow interfacing in networked manufacturing; for example, as Boeing has done for the 787 Dreamliner. The current problems with production can be traced back to selection processes of suppliers (even supported by sophisticated software applications that failed to solve the process of interaction). The lack of synchronization between the possibilities of information technology and the limited understanding of the actual behaviour of entities (or agents for that matter) have only increased instability in relationships, giving greater cause for issues of trust and power fueling uncertainty and opportunistic behaviour. At the same time, interrelationships have become more demanding and have limited the capabilities of parties to operate within each other's constraints. Industrial companies demand partnerships, but these sometimes appear to be forcibly driven by a one-sided strategy rather than being based on a true bilateral relationship. With the reduced capability to maintain long-term relationships, partners in industrial networks need different ways of interacting, sometimes facilitated by applications in information technology and data-communication (extending to both the domain of manufacturing and the domain of product development and engineering).

2.3 Future Networks

There are now many emerging possibilities offered by information technology and data-communication methods. Some of these include planning methodologies (Frederix, 2001), Smart Supply Chains (Noori and Lee, 2002), globalization of markets (Karlsson, 2003) and the ongoing specialization of firms. They drive companies to concentrate on competencies and, consequently, enable them to move from centralized, vertically integrated, single-site manufacturing facilities to geographically dispersed networks of resources (Stock *et al.*, 1999). These simultaneous developments foster the specific characteristics of (international) networks, which require adaptations by companies to fit these characteristics.

2.3.1 Network Configuration

The dilemma with these networks extends to the problem of achieving a balance between having independent agents and controlling processes to meet performance, which requires a strong interaction between these agents. Virtual organizations, which can be considered as a further manifestation of networks, might display instability between the model of pure outsourcing and the establishment of more traditional alliances (Roosendaal, 2000). Even alliances, which are perceived as more stable relationships between firms, usually dissolve over time or result in mergers (Kogut, 1989). The network is optimized locally and creates power shifts if the balance moves towards independence of agents, depending on the uniqueness of their resources (Medcof, 2001). Also, flexibility might be lost in the short and medium term through the creation of alliances or mergers (Mody, 1993). Therefore, research needs to be undertaken to reveal whether this dilemma of balance between control and change in networks can be resolved.

The principal characteristic of industrial networks is their ability to capture market opportunities and to adapt to changes in the environment. Collaboration with other companies has a significant impact on the capabilities of a network. Hitherto, the dynamic capability has equated to “changeability”, which Milberg and Dürrschmidt (2002) define as the sum of (i) flexibility, defined as the capability to operate in a wider space on certain dimensions of business management, and (ii) responsiveness, defined as the ability to handle emerging changes in the environment. Thus changeability is a measure of the total changes the environment demands of an organization or network (Wiendahl and Lutz, 2002). Sometimes, the sacrifices in a given production system to obtain flexibility (i.e. capturing market opportunities and adapting) exceed the derived benefits.

Each market opportunity requires an adequate response from an industrial network. The flexibility of a network relies on the deployment of resources to capture these market opportunities and thereby needs a control structure and organizational structure that fits the actual demand. Theory about organizational design distinguishes the process structure, the control structure, the organelle structure, and the hierarchy (Dekkers, 2000); the organelle structure is based on the grouping of (business) process or activitites to address performance requirements.

The methodology for the design of organizations assumes a linear process when designing each of these structures consecutively, see Figure 2.2, even though this process should be considered iterative. In this approach the design of the organelle structure is key to meeting performance demands by customers; which leads Dekkers and van Luttervelt (2006, p. 13) to propose a model for reconfiguration of networks, see Figure 2.3. Industrial networks provide the opportunity for optimizing each of the four structures to take place independently and that through the connections between these structures, as present in the value chain and as individual agents, optimization will occur over time.

Another phenomenon is the increasing participation of Small and Medium-sized Enterprises (SMEs) in international manufacturing networks (Tesar *et al.*, 2003), which has been enabled through the factors identified by Lall (2000) as contributing to the increase in SME competitiveness. Bennett and Ozdenli (2004) have studied the role of several SMEs in international manufacturing networks. The SMEs were based in industrialized countries, developing countries and transition economies. The analysis of the cases shows that they are motivated largely by the desire to extend their reach and a wish to begin establishing a global presence. It also shows that control and commitment are two major determinants for SMEs and international manufacturing networks, so managers must think carefully about how much control they want to have (or should have) within the network. This concerns the electronic and virtual integration of companies, so calling on totally new models for dealing with networks (Dekkers *et al.*, 2004). These include matchmaking and brokerage through web services (Field and Hoffner, 2003; Molina *et al.*, 2003) and electronic contracts; these will enable companies to move away from the control paradigm for the monolithic company towards management approaches that fit the emergent properties of networks (Angelov and Grefen, 2003; Barata and Camarinha-Matos, 2003). The concept of complex networks with emerging properties strongly relates to the proposed idea of Open Innovation Systems (Chesbrough, 2003; Tidd, 1995);

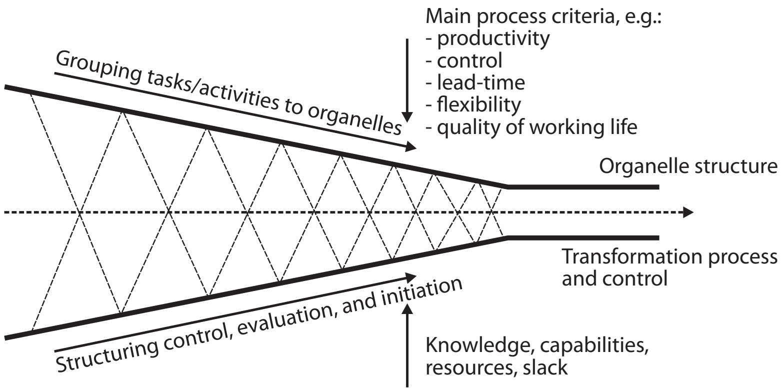

Figure 2.2. *Design process for the organelle structure (Bikker, 1993, pp. 183–188). The organelle structure affects both the grouping of tasks in the primary process as well as the control processes. By subsequent integration and iteration, the design of the organelle structure meets performance requirements.*

the increased interaction between actors in networks requires a rethinking how it happens at all (Dekkers, 2009), whether it concerns manufacturing or innovation and product development.

2.3.2 Manufacturing as a Commodity

An important development influencing the shift in power within manufacturing networks has been the increasing importance of OEMs and, more recently, brand owners (Kotabe and Murray, 2004). Sturgeon (2002) argues that the revival of the American industry during the 1990s can be attributed to what he calls "turnkey" production networks. Essentially, these incorporate the trend towards outsourced manufacturing and an emphasis on branding. To demonstrate this concept, Sturgeon uses the example of the electronics industry, particularly the case of Apple Computer Inc. that contracted SCI Systems for a large part of its manufacturing operations in 1996. A system like a turnkey production network is highly adaptive because it uses turnkey relationships to weave various key production clusters into a global-scale production network based on external economics for OEMs and brand owners.

With the rise in OEMs, especially in the electronics and automotive industries, the concept of outsourcing the production of complete systems and subsystems

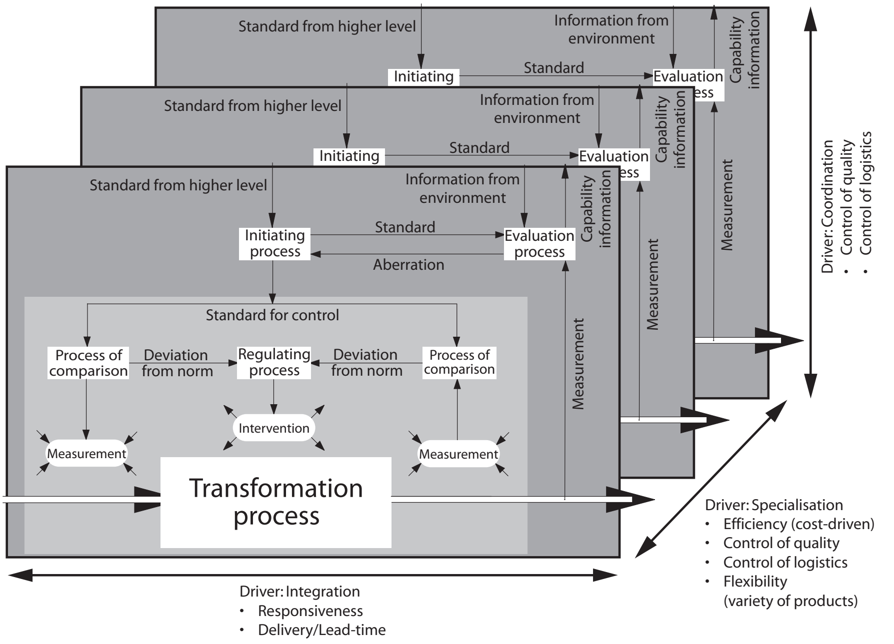

Figure 2.3. *Model for Reconfiguration within networks. Based on different drivers market opportunities call for either integration, specialization or coordination to meet performance requirements. Through predefined organelles for both the primary process and the control processes reconfiguration becomes a preset decision-making process allowing quick responses to changing conditions.*

started to become a common phenomenon. In this way the idea of "tiering" in the supply network was created (Sadd and Bennett, 1999), with power generally reducing towards the lower tiers (with possible exceptions where suppliers are part of much larger companies involved with leading edge technologies). Along with this trend has the idea of manufacturing capacity as a commodity rather than a unique capability for "pushing" products onto growing markets also materialized. At the same time, the focus of technology has also moved upstream with suppliers increasingly turning to advanced manufacturing technologies as a means of competing for orders, while OEMs, especially those based offshore, have tended largely to rely on low-tech assembly techniques for enabling greater agility.

This trend has been taken further under the more recent, and increasingly dominant, regime of brand ownership. A characteristic is the separation of brand from origin of production and the virtually complete transition of manufacturing to a commodity with power residing almost totally with the brand owner; this often causes the brand to be more dominant than the actual product (Joo *et al.*, 2003). In turn, this has led to manufacturing becoming increasingly footloose with international mobility being an important aspect of network design. In particular, this has resulted in the transfer of production capital away from the traditional industrial economies to the low factor cost economies of the Far East and the transition economies of Eastern Europe (Bennett *et al.*, 2001).

2.3.3 Added Value of Industrial Networks

Collaborative efforts, whether or not they are crossing borders, are not only seen as an approach to decrease manufacturing costs; cooperation between network companies is increasingly seen as a means for lowering development costs, accelerating product and process development, and maximizing commercialization opportunities in innovation projects. The capability of building and maintaining inter-organizational networks, such as joint ventures, license agreements, co-development (between suppliers and customers) and strategic alliances has led to more product and process innovations (Ritter and Gemünden, 2003); see Figure 2.4. This also covers the extension of capabilities, with manufacturing services as a newly emerging trend and the capabilities embedded in manufacturing services partly answering the demand for customization.

Both horizontal and vertical collaboration require managing the relationships between actors in the network. Burt (1992) and Uzzi (1997) have demonstrated the general mechanisms by which relationships between firms in supply chains and networks can be explained. As a starting point, they use two different aspects of networks, namely the positioning of firms in the structure of the network and the nature of the mutual relationships. Burt's reasoning implies that the chance of achieving completely radical innovations may decrease if companies establish strong mutual contractual links, such as in supply chains. Links with other companies in the supply chain might be so strong that they prevent a company from successfully implementing an innovation, even if it is in a strategic position to do so. Typically, a successful cooperation strategy consists of three basic elements, i.e. selection of a suitable partner, formulation of clear-cut agreements (getting the project underway), and management of the ongoing relationship. Careful selection of future collaborative partners can prevent many problems and, according to Hagedoorn (1990), the aim should be similarity balanced by complementarity, with similarity referring to the firm's size, resources, and performance. However, of more importance are the required complementarities offered by the cooperation partner, i.e. the combination of complementary activities, knowledge, and skills to realize the desired synergy. The literature on strategic partnerships offers many models to evaluate potential cooperation partners (e.g. Souder and Nassar, 1990). Based on a study of 70 UK based firms in different industry sectors, Bailey *et al.* (1996) even concluded that selecting partners based on their track record in previous collaborations turns out to be a poor basis for future collaboration. These signals indicate that how collaborations can be effectively exploited has not yet been settled.

2.4 Research Agenda for Industrial Networks

The three themes – network configuration, manufacturing as commodity, added value of networks – described in the previous section appear not to be congruent with most of the ongoing research into industrial networks. Nassimbeni (1998) comments that the bulk of available research on networks is devoted to the contractual aspects and social dynamics of inter-organizational relationships, while the dynamic forms of communication and coordination have been neglected, so requiring more attention from researchers. Most likely this originates in the conversion from the hierarchical firm, with direct control of resources and a cross-ownership strategy towards

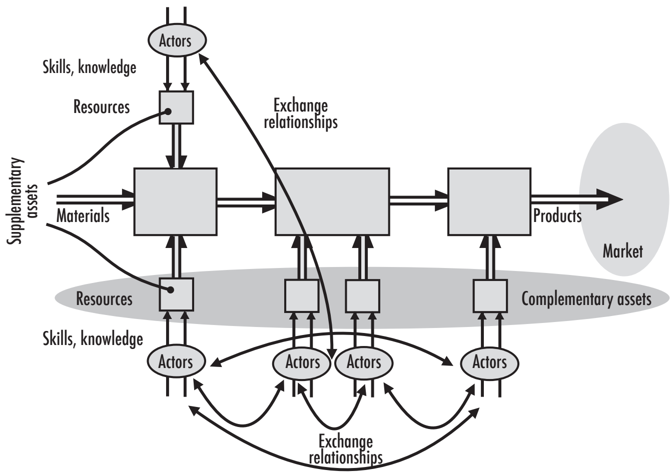

Figure 2.4. *Collaboration Model for the value chain (Dekkers, 2005b, p. 330). Vertical collaboration indicates the capability of actors to manage the supply chain. Horizontal collaboration contributes to the dynamic capability of the network by reallocating resources or creating substitution.*

suppliers, to networks with more loosely connected entities, which is a view also found in Smulder *et al.* (2002).

However, the shift towards more loosely connected entities requires additional theory, models and tools to cope with issues of collaboration, inter-organizational integration and decentralization of decision-making. It is probably more than a decade since the beginnings of academic research into the networked organization (which initially looked at the extended enterprise, etc.). This research has mainly used models from the monolithic company – decision-making on make-or-buy and social dynamics – to further research. Reported findings of research argue that studies should pay more attention to modelling the interaction between agents (Robertson and Langlois, 1995), meaning that a more integrated approach becomes necessary. Therefore, research should consider taking different routes:

- The recent insights in natural sciences and the application of principles of complex systems theory to collaborative enterprise networks as socio-technical systems might yield these complementary approaches. Six themes emerge (Dekkers *et al.*, 2004):
  i. the dynamic description of networks (to respond to market opportunities and shifting demands and to capture the stability of networks themselves);
  ii. coordination possibilities (the networks consist of loosely connected entities, each with their own strategy, and dependent on each other for delivery of products and services);
  iii. radical and integrative innovation (the capturing of new market opportunities and technological prospects, and at the same time taking advantage of individual agent's knowledge and skills);
  iv. path dependency in the evolution of networks (the concepts of evolutionary approaches and concepts like co-evolution and symbiosis applied to industrial networks);
  v. sharing of information across agents (the network as a community of entities that evolve together);
  vi. modelling and representation of industrial networks (to stretch beyond classification and static approaches).

  This might serve as a base for an interdisciplinary research approach.
- Networks operate in dynamic environments and require dynamic approaches, so reflecting Ashby's Law of Requisite Variety (Ashby, 1956). Perhaps even instability rather than stability is a rule, which requires that optimization models should rely on insight from other sciences. Although neural networks incorporate some of these ideas, the explicit criteria of optimization, dispersal, and bifurcation describe the evolution of networks (Dekkers, 2009).
- The efficacy of industrial networks relies on the use of Information and Communication Technology for collaborative engineering, Computer-Aided Production Planning, Supply or Value Chain Management and communication (Maropoulos, 2003; Noori and Lee, 2002), so exceeding the need for logistics integration, which is the main argument of Stock *et al.* (1999). Also, the optimization of structures can be supported by information technology. Helo *et al.* (2006) propose a flexible, integrated web-based logistics management

system for agile supply demand network design, allowing to interface different scheduling agents from different actors. Nevertheless, a lot of development work needs to be done to obtain methodologies, methods and tools to sustain industrial networks as loosely connected entities (Dekkers, 2009).

- The reconfiguration, for which a method should still be developed, allows a more appropriate approach for capturing market opportunities and optimizing performance of networks (see Dekkers and van Luttervelt [2006, p. 19] and Subsection 2.3.1).
- The link between product development and manufacturing needs to be investigated more closely. So far, research has concentrated on Order Entry Points, product families, etc.; but these concepts have limited reach, although they are addressing an important capability of networks: (mass) customization. Particularly, the impact the interface between product development and manufacturing on networks needs attention.

Although the specific research into approaches for networks has progressed, further advances should create insight into optimization and tools to support industrial networks; this is congruent with the remark of Camarinha-Matos and Afsarmanesh (2005, pp. 443-444) that research into Collaborative Networks constitutes a new interdisciplinary domain.

2.5 Conclusion

There is little doubt that the issue of industrial networks has been an important concern to companies needing to compete in the dynamic competitive climate that has demanded greater flexibility, responsiveness and variety as well as responding to pressure on costs. The traditional networks of the past, especially those based on keiretsu or chaibol principles, are less appropriate in today's business conditions and, as a consequence, more loosely connected agile networks have emerged. However, there has been very little research aimed at establishing the patterns that underlie their emergence, and there remains the question of what support such research should provide for practitioners.

This chapter has identified a number of key issues concerning the future of networks, which have been based on a review of the relevant literature and additional considerations. First, network configurations require a control structure and organizational structure that fits actual demand, so companies have started to move away from the control paradigm of the monolithic company towards managing the emergent properties of networks. Second, with the move towards OEMs as network players there has been a greater tendency for manufacturing to become a commodity, which has accelerated under the regime of brand ownership. Third, the added value of industrial networks includes more product and process innovations and the extension of capabilities with manufacturing services. Finally, a number of different routes that research should take if it is to properly reflect and support industrial networks in the coming decade and beyond have been identified.

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