

INDUSTRIAL NETWORKS OF THE FUTURE -A CRITICAL COMMENTARY ON RESEARCH AND PRACTICE

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ABSTRACT

Academia has followed the interest by 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 seems 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 to specialize forces other parts of industrial networks to introduce advanced manufacturing technologies for 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. Fourthly, there will be a continuous move toward more loosely connected entities forming manufacturing networks. More traditional concepts, like keiretsu and chaebol networks, do not sufficiently support this transition. Research should address these fundamental challenges to prepare for the industrial networks of 2020 and beyond.

Keywords: international manufacturing, networks, competitiveness

INTRODUCTION

Changes in how we view companies, as well as the networks within which they operate, have arisen because of the possibilities offered by information technology and data-communication, the globalization of markets and the international networks of companies. Firms now have easier access to the capabilities and resources of others, thereby moving away from the traditional make-or-buy decision; even though this specific decision still attracts attention from researchers to develop more appropriate models (e.g. C  n  z et al., 2000; Humphreys et al., 2002; Probert, 1997). During the 1980s, the concept of co-makership appeared as one of the more advanced approaches for managing the supply chain. Additionally, the world of management has been overfled by theories that might have been adequate to deal with the contemporary challenges for some enterprises but not for others (Fischer and Hafen, 1997; Micklethwait and Wooldridge, 1996); Business Process Re-engineering, Core Competencies, and Lean Production serve as examples of such theories addressing the question of supply chain management. However, do they really deal with the characteristics of networked organizations? Here, the authors argue that industrial networks call for adaptation of existing theories to fit their particular characteristics, and the development of grounded theories based on the unique features of collaboration.

History of industrial networks

The attention paid to particular characteristics of networked organizations is not just a recent phenomenon (Wiendahl & Lutz, 2002). In particular, academic interest has risen during two periods. The first of these is was during the 1970s and 1980s when attention was focused on Japanese manufacturing concepts and techniques, including JIT (just-in-time), co-makership and keiretsu networks. The second period started during the 1990s as a consequence of the drive for even lower cost, greater efficiency and responsiveness to customer demands. This resulted in the networked organization following the paradigm of core competencies and consequently the move towards outsourcing. The overview by Miles & Snow (1984) illustrates the move from the simpler paradigms to the more complicated forms of network-based organizations that we have witnessed during the past years (see Table 1).

Since Skinner’s seminal work (Skinner, 1969), manufacturing has been recognized as a fundamental cornerstone for achieving competitive advantage. However, most companies have still maintained efficiency as the main objective of their production departments (Avella, 1999). Initially, during the 1960s and the 1970s, the make-or-buy decision was at the heart of operations management research. In the 1980s, the interest in Japanese manufacturing techniques, including their collaboration with suppliers, sparked the next step into models for collaboration and supply chain management using JIT principles. Then in the early 1990s the introduction of the core competencies concept 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), but the increasing attention paid to networks has not challenged the proposition of Skinner that manufacturing is of paramount importance to industrial performance.

Table 1- Evolution of Organisational Forms (Miles and Snow, 1984)

Period	Product-market strategy	Organisation 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, standardised 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 polices and division profit centres.
1950 -	Standard and innovative products or services. Stable and changing markets.	Matrix	Several aerospace and electronic firms (e.g. NASA, TRW, IBM, Texas Instruments)	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.

The impact of globalization

The current developments in information and communication technology, globalization and specialization foster the specific characteristics of industrial networks, i.e. collaboration, decentralization, and inter-organizational integration (O’Neill & Sackett, 1994). Each change itself in these three fields requires adaptations by companies and the interference of several of these shifts leverages 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 development over time (decentralization).

The attitude towards resource allocation has changed due to the emergence of the paradigm of industrial networks. The need for proximity of supply, following the theories about co-makership, required a strong interaction between customer and supplier. Consequently much research focused on the need for economic clusters (e.g. Porter, 1990). Only recently, these preferences are changing, like Daimler Chrysler's announcement that suppliers need to deliver in six days (rather than 1-2 days previously with physical proximity). This only illustrates the different view on supplier selection and purchasing management emerging now.

Not only has the scene for suppliers to any industry changed but many more countries have also followed an active path towards developing relevant competencies. For example, the Thai government has deliberately strengthened the automotive sector by attracting companies in that industry. In contrast, at the end of the 1990s, MIT undertook a study which led to a warning about the decline of manufacturing industry in the USA. Recently the USA has adopted a more progressive approach with the study on Visionary Manufacturing Challenges (National Research Council, 1998) and also the UK government has stimulated the founding of Innovative Manufacturing Research Centres. Consequently a complex pattern has emerged with the industrial base undergoing shifts by moving to developing countries, new countries entering the manufacturing scene, and a revival of some industrialized countries, making it all the more dynamic than ever before.

Scope of paper

In the past, the external drivers (the move from make-or-buy to co-makership or alliances and the drive for flexibility of manufacturing), and the internally oriented concepts (the attempts to apply Computer Integrated Manufacturing and the use of production cells) demonstrate a continuous move towards more loosely connected industrial entities. The requirement for greater flexibility has also touched on the increasing degree of customization and production of goods on demand (see Lee & Lau, 1999). Contemporary changes in industry point to a further repositioning along the dimension of loosely connected entities with increasing pressure on responses to market opportunities and flexibility.

This paper explores the concept of industrial networks for manufacturing following this move. It aims to present a visionary approach to industrial networks of the future, i.e. to 2020 and beyond, based on ongoing research and additional considerations. Increasingly firms are operating as part of industrial networks, although the situation is extremely fluid and the stage has not yet been reached where networks are optimally configured and network operations are at the stage of maturity.

Initially, this paper takes a historical perspective by examining the types of network that have been identified together with the reasons they have been formed and their advantages and weaknesses. This includes a critique of the traditional "keiretsu" and "chaebol" networks based on conglomerate structures that formed the basis of Japan's and Korea's economic success, but more recently have proved incapable of achieving the need for speed of change, flexibility, and cost cutting 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 started to encounter severe problems, making them rethink their plans to create similar supply networks (Stein, 2002).

Traditional Views on Networks

Within the overall primary process, the connection between product development and manufacturing strategy has not yet resulted in conceptual approaches for establishing this vital link. Driven by a study into sequential and simultaneous approaches to engineering, Riedel & Pawar (1998) highlight that the concepts of design and manufacturing are not linked in literature and that the interaction of product design and manufacturing strategy is under-researched. Spring &

Dalrymple (2000) came to the same conclusion when examining two cases of product customization, where manufacturing issues got little attention during design and engineering. Henceforth, the upcoming paradigm of industrial networks, if they are to be successful, should address this matter. Three mainstream concepts in this area dominate thinking in operations management: core competencies, agile manufacturing networks, and keiretsu and chaebol networks.

Core competencies and outsourcing

According to Friedrich (1996), focusing on core competencies (Prahalad & Hamel, 1990) and outsourcing raises the key issue of which areas of production are needed to maintain the value added chain and on which key areas the company should concentrate for achieving optimal performance. Prahalad & Hamel subtly expand the view of technology from a broadly described feature whose importance is determined by its support of the corporate mission, to a specific source of corporate uniqueness. In their view core competencies represent the collective learning of the organization, especially 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. Only when we link core competencies to decision-making, will we find a manufacturing strategy presenting guidelines for decision-making on resource acquisition and capacity management (Hayes & Pisano, 1994).

Today, many approaches to outsourcing rely on the deployment of criteria derived from the traditional make-or-buy decisions. However, the rise of industrial networks creates the need for frameworks that account for early supplier involvement, collaboration, and inter-organizational integration. Also, decision-making on resource allocation has shifted from one-time decisions to continuous evaluation and reallocation. Current approaches hardly account for this; hence the need for expansion of criteria to those suitable for networks. Current practices for management and control of outsourcing still largely depend on the focus on costs and meeting delivery schedules. Research into outsourcing has not yet investigated the impact of industrial networks as such. (Dekkers et al., 2002).

Agile manufacturing networks

Agile manufacturing relies more strongly on the exploitation of loosely connected networks than earlier concepts like Lean Production (Nagel et al., 1991). Co-makership, succeeded by Lean Production, already introduced a higher degree of outsourcing and improved control by Supply Chain Management, although here the networks used were more closely connected keiretsu or chaebol 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 from 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 due time, and taking advantage of changes as opportunities. This would mean that an agile manufacturing enterprise marshals the best possible resources to provide innovative (often customized) products, with the flexibility to adjust the product and to deliver rapidly, and with the high level of efficiency required to be competitive and profitable (Goldman & Nagel, 1993). The concept of agile manufacturing stresses two main interconnected processes:

- the development of innovative products;
- the manufacturing and distribution of products.

These two processes should meet the requirements of lead-time (time-to-market, time-to-volume and delivery time) and flexibility (market opportunities and response to market demands). A re-configurable structure becomes a prerequisite to optimize the capabilities of an organization for each business opportunity (Ross, 1994), which in itself requires more loosely connected entities.

However, even the new types of agile manufacturing network often are 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 Embraer (Empresa Brasileira de Aeronáutica SA) which, with its network of risk sharing partners, was able to accelerate the development and launch of the ERJ-170/190 series of regional jets.

The international dimension to designing agile manufacturing networks is also considered by Lee & Lau (1999) who use the example of firms in Hong Kong and the Pearl River Delta to provide a “factory on demand” within the context of global manufacturing networks. Shi & Gregory (1998) have also contributed by proposing a method of mapping configurations of international manufacturing networks as a means of providing support for international decision-making.

Keiretsu and chaebol networks

A major weakness of the traditional keiretsu and chaebol networks has been their domestic focus and cross-ownership between companies in the network. This has made them incapable of responding effectively to the globalization of manufacturing. It has also created difficulties as end-product manufacturers have moved offshore and the burden of debt resulting from borrowing to support cross ownership has inhibited their ability to fully support international operations. Consequently 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).

Yet, a study by McGuire & Dow (2003) 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 in the 21st century. 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 has therefore been to propose the creation of agile networks based on the principles of agility that have been developed for manufacturing (Tian et al., 2002).

FUTURE NETWORKS

The emerging possibilities of information technology and data-communication, the globalization of markets (e.g. Karlsson, 2003), and the ongoing specialization of firms drive companies to concentrate on competencies. These simultaneous developments foster the specific characteristics of (international) networks of companies, which require adaptations by companies to fit these characteristics.

Network configuration

The dilemma facing these networks extends to the balance between having independent agents and controlling processes to meet performance, which requires a strong interaction between the agents. Virtual organizations, seen as a further manifestation of networks, might display instability between pure outsourcing as a model and establishing alliances (Roosendaal, 2000). Even alliances, which we perceive as more stable relationships between firms, dissolve over time or end up in mergers

(Kogut, 1989). If the balance shifts to independence of agents, depending on their uniqueness of their resources, the network optimizes locally and creates power shifts (Medcof, 2001). Flexibility might be lost in the short and medium term through the creation of alliances or mergers (Mody, 1993). Research should reveal whether this dilemma of balance between control and change in networks might be resolved.

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

Each market opportunity requires an adequate response from an industrial network. The flexibility of a network relies on the deployment of resources to capture market opportunities and thereby needs a control structure and organizational structure that fits the actual demand. The theory about organizational design distinguishes the process structure, the control structure, the organic structure, and the hierarchy (Dekkers, 2002). The methodology for the design of organizations assumes a linear process when designing each of these structures consecutively. Industrial networks provide the opportunity that optimization of each structure takes place independently and that through the connections between these structures, as present in the value chain and as individual agents, optimization will happen 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. This concerns the electronic and virtual integration of companies calling on totally new models for dealing with networks (Dekkers et al., 2004); companies have started to move away from the control paradigm of the monolithic company towards managing the emergent properties of networks. The concept of complex networks with emerging properties strongly relates to the proposed Open Innovation Systems (Chesbrough, 2003).

Manufacturing as commodity

An important development influencing the shift in power within manufacturing networks has been the emergence of OEMs (Original Equipment Manufacturers) and, more recently, brand owners (Kotabe and Murray, 2004). With the rise in OEMs, especially in the electronics and automotive industries, the concept of outsourcing production of complete systems and subsystems 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 also materialized the idea of manufacturing capacity as a commodity rather than a unique capability for “pushing” products onto growing markets. At the same time, the focus of technology has also moved upstream with suppliers increasingly turning to advanced manufacturing technologies to compete for orders, while OEMs have relied on low-tech assembly techniques to enable greater customer responsiveness and agility.

This trend has been taken further under the more recent, and increasingly dominant, regime of brand ownership. A characteristic of this regime 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, with often the brand being more dominant than the actual product (Joo, Nakamoto and Nelson, 2003). This has led to manufacturing becoming increasingly footloose with international mobility being an important aspect of network design. In particular this has

resulted in a 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.

Added value of industrial networks

Cooperation for innovation 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, (supplier-customer) co-development and strategic alliances has led to more product and process innovations (Ritter & Gemunden, 2003). This also covers the extension of capabilities with manufacturing services as a newly emerging trend. Partially, the capabilities embedded in manufacturing services answers the demand for customization.

Burt (1992) and Uzzi (1997) have formulated the general mechanisms by which relationships between firms in supply chains and networks can be explained. They use as the starting point two different aspects of networks, namely the positioning of the 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 the 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. Carefully selecting future cooperation partners can prevent many problems. According to Hagedoorn (1990), one should aim at *similarity balanced by complementarity*, with similarity referring to the firm's size, resources, and performance. However, of more importance is the required complementarities offered by the cooperation partner; the combination of complementary activities, knowledge, and skills realizes the desired synergy. The literature on strategic partnerships offers many models to evaluate potential cooperation partners (e.g. Souder & Nassar, 1990). Bailey et al. (1996), based on a study of 70 UK based firms in different industry sectors, even conclude that selecting partners based on their track record in previous collaborations turns out to be a poor basis for collaboration.

RESEARCH AGENDA FOR INDUSTRIAL NETWORKS

Nassimbeni (1998) remarks that the bulk of available research on networks is devoted to these contractual aspects and the 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 suppliers, to the networks with more loosely connected entities.

About a decade has passed since academic research was started into the networked organisation (initially by looking at the extended enterprise, etc.). Reported findings of the research argue that studies should pay more attention to modelling the interaction between agents, thereby meaning that a more integrated approach becomes necessary. Therefore, future research should consider taking different routes:

- The recent insight in natural sciences and the application of principles of complex systems theory from natural sciences to collaborative enterprise networks as socio-technical systems might yield these complementary approaches. Six themes emerge from this point of view: dynamic description, coordination possibilities, radical/integrative innovation, path dependency, information sharing, modelling & representation (Dekkers et al., 2004). This serves as a base for an interdisciplinary research approach.
- Networks operate in dynamic environments and require dynamic approaches, so meeting Ashby's Law of Requisite Variety (Ashby 1958). 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.

- 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. Also, the optimization of structures can be supported by IT. Yet, a lot of development work should be done to obtain methodologies, methods, and tools to sustain industrial networks.
- The reconfiguration, for which a method still should be developed, allows a more appropriate approach for capturing market opportunities and optimizing performance of networks.

Although the specific research into approaches for networks has progressed, further advances should create insight into optimization and tools to support industrial networks.

CONCLUSION

There is no doubt that the issue of industrial networks has been of intense concern to companies needing to complete 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 based on keiretsu or chaebol principles are no longer relevant to today's business conditions and more loosely connected agile networks have emerged as a consequence. However, there has been little research carried out that is aimed at establishing the patterns that underlie their emergence and there is still a question of what support such research should provide for practitioners.

In this paper there are a number of key findings concerning with future networks, which has been based on a review of the relevant literature and additional considerations. These are, firstly, that network configurations require a control structure and organizational structure that fits the actual demand and that companies have started to move away from the control paradigm of the monolithic company towards managing the emergent properties of networks. Secondly, 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 owners. Thirdly, 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 have been identified that research should take if it is to properly reflect and support the real needs of industrial networks of 2020 and beyond.

REFERENCES

- Avella, L., (1999), "Focal points in manufacturing strategic planning in Spain", *International Journal of Operations and Production Management*, Vol. 19, No. 12, pp. 1291-1317.
- Ashby, W. R., (1958), "Requisite variety and its implications for the control of complex systems", *Cybernetica*, Vol. 1, No 2, pp. 83-99.
- Bailey, W.J., and Masson, R., Raeside, R., (1996), "Choosing successful technology development partners: A best practice model", in *Proceedings of the 6th International Forum on Technology Management*, Amsterdam, pp. 271-283.
- Burt, R.S., (1992), *Structural holes: The social structure of competition*, Harvard University Press, London.
- Business Week, (1999), "Time to Overhaul Japan's Keiretsu Model", *Business Week*, Issue 3620, March.
- Cáñez, L.E., and Platts, K., Probert, D.R., (2000), "Developing a framework for make-or-buy decisions", *International Journal of Operations & Production Management*, Vol. 20, No. 11, pp. 1313-1330.
- Chesbrough, H.W., (2003), *The new imperative for creating and profiting from technology*, Harvard Business School, Boston.
- Dekkers, R., (2002), "Organelle Structures: Bridging Strategy and Technological Processes", in Proceedings of the 10th International Manufacturing Conference in China, Xiamen [CD-ROM].

- Dekkers, R., and Wang, L., Zhang, S., (2002), "Management and Control of Outsourcing in Dispersed Manufacturing Networks", in Proceedings of the 10th International Manufacturing Conference in China, Xiamen [CD-ROM].
- Dekkers, R., and Sauer, A., Schöning, M., Schuh, G., (2004), "Collaborations as Complex Systems", in Gregory, M., and Shi, Y. (eds.), *Designing and Operating Global Manufacturing & Supply Networks*, Proceedings of the 9th Annual Cambridge International Manufacturing Symposium, IMNet/CIM, Cambridge, pp. 60-77.
- Fischer, D., and Hafen, U., (1997), "Immer wieder die gleichen Fehler; Weshalb Reengineering-projekte in KMU so oft scheitern", *io Management*, Vol. 66, No. 6, pp. 38-45.
- Friedrich, S.A., (1996), "Outsourcing: Wie strategische Fehler vermieden werden können", *io Management*, Vol. 65, No. 9, pp. 70-74.
- Goldman, S.L., and Nagel, R.N., (1993), "Management, technology and agility: the emergence of a new era in manufacturing", *International Journal of Technology Management*, Vol. 8, No. 1/2, pp. 18-38.
- Goldman, S.L., and Nagel, R.N., Preiss, K., (1995), *Agile competitors and virtual organization; strategy for enriching the customer*, Van Nostrand Reinhold, Princeton.
- Hagedoorn, J., (1990), "Organizational modes of Inter-firm Co-operation and Technology Transfer", *Technovation*, Vol. 4, pp. 15-23.
- Hayes, R.H., and Pisano, G.P., (1994), "Beyond World Class: The New Manufacturing Strategy", *Harvard Business Review*, Jan.-Feb. 1994, pp. 77-86.
- Humphreys, P., and McIvor, R., Huang, G., (2002), "An expert system for evaluating the make or buy decision", *Computers & Industrial Engineering*, Vol. 42, No. 2-4, pp. 567-585.
- Joo, M-S., Nakamoto, K. and Nelson, J.E., (2003), "The shielding effects of brand image against lower quality countries-of-origin in global manufacturing", *Journal of Business Research*, Vol. 56, No. 8, pp. 637-646.
- Karlsson, C., (2003), "The development of industrial networks: Challenges to operations management in an extraprise", *International Journal of Operations & Production Management*, Vol. 23, No. 1, pp. 44-61.
- Kidd, P.T., (1995), *Agile manufacturing, forging new frontiers*, Addison-Wesley, London.
- Kogut, B., (1989), "The stability of joint ventures: Reciprocity and competitive rivalry", *The Journal of Industrial Economics*, Vol. 38, No. 2, pp. 183-198.
- Kotabe, M. and Murray, J.Y., (2004), "Global sourcing strategy and sustainable competitive advantage", *Industrial Marketing Management*, Vol. 33, No. 1, pp. 7-14.
- Lall, S., (2000), "Strengthening SMEs for international competitiveness", *ECES Working Paper*, No. 44.
- Lee, W.B., and Lau H.C.W., (1999), "Factory on Demand: The Shaping of an Agile Production Network", *International Journal of Agile Management Systems*, Vol 1, No 2, pp. 83-87.
- McGuire, J., and Dow, S., (2003), "The persistence and implications of Japanese keiretsu organization", *Journal of International Business Studies*, Vol. 34, No. 4, pp. 374-388.
- Medcof, J.W., (2001), "Resource-based Strategy and Managerial Power in Networks of Internationally Dispersed Technology Units", *Strategic Management Journal*, Vol. 22, pp. 999-1012.
- Micklethwait, J., and Wooldridge, A., (1996), *The witch doctors*, Heinemann, London.
- Miles, R.E., and Snow, C.C., (1984), "Fit, Failure and the Hall of Fame", *California Management Review*, Vol. 26, No. 3, pp. 11-28.
- Milberg, J., and Dürschmidt, S., (2002), "Planning Methodology for Changeable Logistic Systems", *Production Research*, Vol. 9, No. 1, pp. 63-68.
- Mody, A., (1993), "Learning through alliances", *Journal of Economic Behaviour and Organization*, Vol. 20, pp. 151-170.
- Mraz, S., (1997), "Building a Manufacturing Network", *Machine Design*, Vol. 69, No. 16, pp 85-89.
- Nagel, R.N., and Dove, R., Goldman, S., Preiss, K., (1991), *21st Century Manufacturing Enterprise Strategy: An Industry Led View*, Iacocca Institute/Lehigh University, Bethlehem.
- Nassimbeni, G., (1998), "Network structures and co-ordination mechanisms, a taxonomy", *International Journal of Operations and Production Management*, Vol. 18, No. 6, pp. 538-554.
- National Research Council, (1998), *Visionary Manufacturing Challenges for 2020*, National Academies Press, Washington.

- O'Neill, H., and Sackett, P., (1994), "The Extended Manufacturing Enterprise Paradigm", *Management Decision*, Vol. 32, No. 8, pp. 42-49.
- Porter, M., (1990), *The Competitive Advantage of Nations*, MacMillan, Houndmills.
- Prahalad, C.K., and Hamel, G., (1990), "The Core Competence of the Corporation", *Harvard Business Review*, Vol. 168, No. 3, pp. 79-91.
- Probert, D., (1997), *Developing a make or buy strategy for manufacturing business*, Institution of Electrical Engineers, London.
- Riedel, J.C.K.H., and Pawar, K.S., (1998), "The strategic choice of simultaneous versus sequential engineering for the introduction of new products", *International Journal of Technology Management*, Vol. 6, No. 3/4, pp. 321-334.
- Ritter, T., Gemunden, H. G., (2003), "Network competence: Its impact on innovation success and its antecedents", *Journal of Business Research*, Vol. 56, No. 9, pp. 745-755.
- Roosendaal, C., (2000), *The concept of the virtual organisation*, Delft University of Technology/Section Industrial Organisation and Management, Delft.
- Ross, E.M., (1994), "The twenty-first century enterprise; agile manufacturing and something called CALS", *World class design to manufacture*, Vol. 1, No. 3, pp. 5-10.
- Sadd, R. J. and Bennett, D. J., (1999), "Automotive Supply Logistics: Myth and Reality", in Muffatto M and Pawar K (Eds) *Logistics in the Information Age*, Proceedings of the 4th International Symposium on Logistics, Servizi Grafici Editoriali, Padova, Italy, pp. 345-352.
- Shi, Y, and Gregory, M., (1998), "International manufacturing networks - To develop global competitive capabilities", *Journal of Operations Management*, Vol. 16, No. 2/3, pp. 195- 214.
- Skinner, W., (1969), "Manufacturing: Missing Link in Corporate Strategy", *Harvard Business Review*, Vol. 47, No. 3, pp 136-145.
- Souder, W.E., and Nassar, S., (1990), "Choosing an R&D Consortium", *Research & Technology Management*, Vol. 33, No. 2, pp. 35-41.
- Spring, M., and Dalrymple, J.F., (2000), "Product customisation and manufacturing strategy", *International Journal of Operations & Production Management*, Vol. 20 No. 4, pp. 441-467.
- Stein, T., (2002), "Keiretsu Comedown", *Investment Dealers' Digest*, Vol. 68, No. 6, pp 28-36.
- Tesar, G., Boter, H. and Bohman, H., (2003), "Network participation and internationalisation of smaller manufacturing enterprises in Central Europe: A Case for Research", *Proceedings of 19th annual IMP Conference*, University of Lugano, 4 – 6 September, Lugano, Switzerland.
- Tian, G.Y., and Yin, G., Taylor, D., (2002), "Internet-based manufacturing: A review and a new infrastructure for distributed intelligent manufacturing", *Journal of Intelligent Manufacturing*, Vol. 13, No. 5, pp 323-338.
- Uzzi, B., (1997), "Social Structure and Competition in Interfirm Networks: the Paradox of Embeddedness", *Administrative Science Quarterly*, Vol. 42, pp. 35-67.
- Wiendahl, H.-P., and Lutz, S., (2002), "Production in Networks", *Annals of the CIRP*, Vol. 51, No. 2, pp. 573-586.
- Zachary, K., (2001), "Dismantling the Keiretsu", *Ward's Auto World*, Vol. 37, No. 5, pp. 54-55.
- Zhang, A., (2002), "Going abroad – China's multinationals in the making", *China-Britain Trade Review*, October, pp. 14-16.