

Linking Manufacturing Strategies to Design of Production Systems in
Collaborative Manufacturing Networks

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Abstract

Competition has forced companies to collaborate in manufacturing network settings to be capably to deliver complete subsystems. We suggest in this paper an analytical tool to analyze the linkages between manufacturing strategies and design of production systems in collaborative manufacturing network settings. We show how this analytical tool might be used to analyze how companies in such networks synchronize their manufacturing strategies and production systems in terms of competitive priorities and synergies between them. The findings in this paper are based on a series of interviews with people at companies in a collaborative network delivering heavy vehicles.

Key words: Manufacturing strategies, production systems, collaborative networks, competitive priorities, supply chain

1 Introduction

Traditionally, manufacturing has been seen as important for the financial results of a company and has gained much interest over the years. However, Skinner showed that manufacturing process had been put aside in the favor of financial and marketing influences in many companies (Skinner, 1969). Manufacturing process in western companies has thus lost its central role in management of organizations and it has also lost its influence on the company's long-term development. Japanese organizations, especially Toyota, in contrast to the US and European companies, have however been identified to be very successful in using the manufacturing process to gain competitive advantages and have consequently also been the object for many case studies (e.g. Hayes and Wheelwright, 1984; Hill, 1995; Monden, 1998; Schonberger, 1983). One major reason for the success of Japanese companies in general, and Toyota in particular, is their ability to develop close relations and high involvement of suppliers in product development as well as in production. The Japanese companies have introduced new approaches to manufacturing, known as lean production system, which uses a smaller number of suppliers, who are participating in early product development phases and who have responsibility for manufacturing of complete sub-systems or larger modules (Womack et al., 1990). The Japanese way of working with suppliers requires a high level of integration between the preferred suppliers and the systems integrator (Lamming, 1993). For this reason, the potential benefits of strategic alliances between systems integrator and its suppliers have received considerable attention (Fruin, 1992; Lamming, 1987; Lamming, 1989; Lyons et al, 1990; Quinn, 1992). The incorporation of suppliers into the firms' product development is considered as one major key to a shorter development cycle and better products (Clark & Fujimoto, 1991). Some researchers claim that strong ties between a firm and its external suppliers may have a considerable impact on the firm's flexibility and shortening of lead-time in product development as well as in manufacturing (Imai et. al., 1985).

Prasad (1996) claims that systems integrator-supplier collaboration can be handled in three distinctive ways: (1) Specification and formal purchase contracts, (2) Two-phase contractual agreement in which the purchasing process is divided into two phases incorporating major suppliers or trading partners, and (3) Partnership and mutual learning. In addition, three different types of partnership may be recognized. In the *strategic* type, customers include subcontractors and suppliers as partners from the beginning. The *tactical* partnership is project based and short-term oriented. The tactical partnership is not used for components or technologies that might be classified as the "core" or "strategic" type, or "operational". The third, *operational*, partnership is more peripheral. This type of collaboration includes transportation, shipment, raw materials supply, procurement, purchasing, legal matters, etc. It has been shown that the strategy for high level of supplier integration in product development on the business level (in Prasad terms labeled as the strategic type) needs to be supported by appropriate project structure and design of collaborative work breakdown structure and work packages (Danilovic, 1999, 2001).

In these approaches, focusing on high level of integration between systems integrators and suppliers, manufacturing aspects are neither highlighted at the systems integrating company nor at the supplying companies. Thus, the strategic aspects, aiming at more intense collaboration between purchasing company and its suppliers, might need to include strategies for developing manufacturing processes enabling integration in manufacturing and production as well as in product development. These processes should support close collaboration that is intentional

when seeing relations between purchasing and supplying companies as strategic alliances or partnerships (Slack et. al., 2001).

The concept of world-class manufacturing, which has been discussed by many scholars (e.g. Hayes and Wheelwright, 1984; Hall, 1987; Schonberger, 1996), is applicable also for collaborative manufacturing networks. Some scholars are claiming that if a company is going to be able to use its internal and its external manufacturing resources in a competitive way, there must be a clear idea of how the manufacturing processes should support the business idea and the desire to have close involvement of suppliers in manufacturing as well. In this perspective, manufacturing strategies, which aim a few years into the future, are necessary to be seen as an important strategic issue for a company's competitiveness and survival (e.g. Skinner, 1992; Hill, 1995).

In our research we have formulated three hypotheses related to the issue of relations between manufacturing strategies and design of production systems among companies in a collaborative network setting.

Our first hypothesis is that manufacturing partnership between a systems integrator and its suppliers, on the business level, needs to have a supportive manufacturing strategy on the network level supported by manufacturing strategies on the corporate level in each company on the network.

Our second hypothesis is that high level of manufacturing integration between systems integrator and its suppliers, on the tactical or project level, needs to be supported by the design of production systems within each participating company enabling delivery of complete systems to customers.

Our third hypothesis is that synchronization of manufacturing strategies and production systems among companies within a collaborative network setting should be based on a shared view of the competitive situation that the systems integrator and its suppliers are facing as a collaborative network.

2 Research Approach and Research Methodology

Our approach to the formulated hypotheses in this research is to apply an analysis model originally based on research of relations between manufacturing strategy and design of manufacturing system within a single company (Miltenburg, 1995; Säfsten & Winroth 2002). This model has been extended in the analysis of a dyadic relation between two companies (Winroth & Danilovic, 2002). In this research we attempt to investigate how this analytical model can be applied to a network setting, in which one systems integrator have close collaboration with three suppliers.

This research is based on a series of interviews with people at all four companies involved in a collaborative network. We have also studied how this manufacturing network works in order to produce and deliver the complete systems to customers. We have performed four interviews that have been recorded, typed and double checked with the interviewees. Mapping of corporate strategy and their manufacturing design presented in this paper have been performed on the basis of collected information in interviews and is thus our interpretation of the circumstances at hand within each company and between companies.

3 Approaches to Manufacturing Strategies and Production Systems design

Introduction

The issue of how the manufacturing strategies and the design of the production system influence each other was investigated by e.g. Miltenburg (1995). The original analysis framework was built up by three main parts: a table showing the competitive situation of the company (or the business area where the specific product competes), a diagram classifying the production system into one of seven production systems and showing the support for different competitive factors, and finally a list of six decision categories that together show the manufacturing strategy of the company. They were graded according to a four-degree scale, ranging from internally neutral to externally supportive (or ‘infant’ to ‘world-class’), i.e. how they support the overall business strategy of the company. The list was the same as Hayes and Wheelwright presented (1984), with the exception that Miltenburg excluded quality management and capacity in his model.

Single corporate setting

Säfsten and Winroth (2002) elaborated further on the analysis model, with the aim of making it a more easy to use tool. The changes to the model were not extensive, but the number of support squares in the center of Figure 1 was reduced to only two and the number of decision areas (called “Manufacturing levers” by Miltenburg) was increased to the ‘original’ eight, since quality and capacity criteria were considered to be extremely important. The number of production systems was reduced, since Just-In-Time and Flexible Manufacturing System are not really production systems but more of philosophies on how to organize the production and supply of components to the system. Finally, the number of steps when performing the analysis was increased from three to five in order to make the process clearer and easier to understand. The developed model is shown in Figure 1.

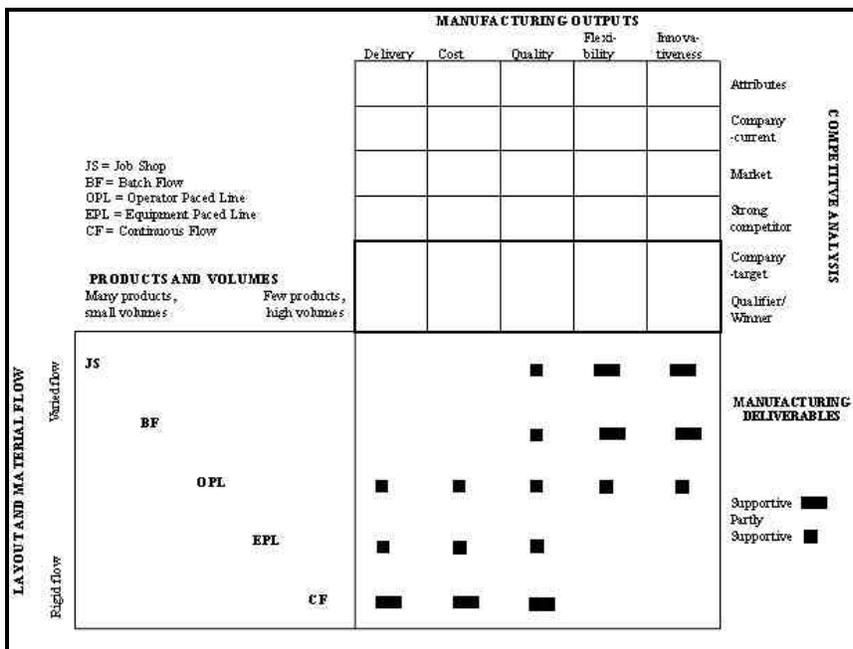


Figure 1. Strategy analysis model (Säfsten and Winroth, 2002, adapted from Miltenburg, 1995).

The analysis is performed in a five steps according to Figure 2.

Survey of current position	Analysis of congruence
<p>Step 1</p> <p>The survey of the current manufacturing capability. Positioning of the capability into one of the four levels, ranging from ‘infant’ to ‘world class’.</p> <p>Step 2</p> <p>The ‘five manufacturing systems’ plus Flexible Manufacturing Systems, FMS, and Just-In-Time, JIT.</p> <p>Step 3</p> <p>Which factors are considered important for the company’s competitive ability? Where are the competitors and where does the company want to be?</p>	<p>Step 4</p> <p>Each manufacturing system shows different support for the competitive factors. Does the present manufacturing system support the competitive priorities of step 3?</p> <p>Step 5</p> <p>Identify possible and suitable changes. Does the analysis imply that the manufacturing system should be changed or that there is a mismatch between the decision areas of the manufacturing capability study in step 1?</p>

Figure 2. The five steps of the analysis (Säfsten and Winroth, 2002).

The framework is intended for analyzing a single production system, which often is only a limited section of the company.

Companies are, however, open systems and there are always input and output relationships with the environment. In network settings several companies have to collaborate and each of these companies needs to have a set of manufacturing strategies comprising different design production systems.

Dyadic setting

The framework was applied at two companies and showed to be a usable tool to identify relations between manufacturing strategies and necessary changes of production systems according to identified decision areas between a systems integrator and a supplier (Winroth & Danilovic, 2002). One conclusion of their work is that the developed congruence analysis framework was applicable for finding the most supportive production system for each company. The analysis model is however semi-closed and limited to a single organization. The possibilities of including the dynamic interaction with other companies in collaborative settings are small. Thus it is not suited for synchronization between companies. Parts of the framework could however be used and the most important conclusions are:

- The companies share the same competitive situation regarding the mutual product.
- Their production systems do not need to be similar, but they must support each other.
- The production systems are the results of the manufacturing strategies and the respective decision criteria of the companies could be correlated to each other.

The question raised was how the analytical framework could be used on the network level, considering the interaction between a systems integrator and suppliers, partners, or customers. Is it possible to apply the framework in these more complicated situations in order to gain

understanding of how each of these companies in a network setting can develop manufacturing strategies and production systems that can enhance their capability to manufacture and deliver complete systems?

4 Empirical investigation of a collaborative network

Introduction

The incentives for forming collaborative company networks vary, but there is often an idea behind that the companies are preparing for the future and instead of continuing as only suppliers of parts, they can together with partners with complementary competences act as one supplier, taking larger responsibility for delivering larger systems or sub-systems. As companies enter close collaborations in network settings they face large opportunities, which they can not achieve alone. Together the network gains in competence and strength, thus being able of accepting larger responsibility in terms of competence, capacity and financial strength. A prerequisite for achieving these results is, however, that the companies must be supportive to each other regarding supply capability. The individual production systems should be coordinated in order to together support the overall aims of the network. At the same time, the actors of a collaborative network setting are often involved in other networks or supplying a specific customer. This means that they can not focus the design of the production system and support functions totally on just one situation. They must keep the flexibility and thus making trade-offs in order to be able to continue to produce a variety of products or parts. A wider presentation of different issues around network collaboration, necessary organizational actions to take, and factors important to the network if it will succeed was made by Winroth and Danilovic (2002).

Case study

The companies of this collaborative network are all parts of large multinational industrial groups, with head-offices outside of Sweden. The SI has approximately 350 employees, out of which 200 are occupied with a large order for military purposes. The supply was previously managed from the partners facilities located between 40 and 80 kilometers away. This caused however problems since the SI competes, among other things, by being able of accepting very late changes. Sometimes the customer wants to make extensive changes even at the final on-site inspection. The main reason why the SI wanted to get closer and more developed cooperation with the suppliers was that, as they got a military order, they faced a lack of work shop area and the owners would not let them expand. The military customer wanted the company to keep the final assembly in their own premises and consequently they had to outsource more of the parts manufacturing to external suppliers. Three key suppliers, who all had been supplying to the SI for many years, were offered to establish small branches very close to the SI. Since the SI also put up financial guarantees that the new establishments would be cost neutral and that the suppliers also could get larger scope of delivery, taking over some work tasks even inside the SI's premises, they accepted the offer. The SI could also reduce its own personnel since no purchaser is needed. There are only general purchasing agreements, and the amount of people handling the supply of components could be reduced. SI's planning system is now 'transparent', i.e. the suppliers have direct access to seeing planned orders and they can guarantee that the right components will be in stock at the right time.

Analysis

First each company performs an analysis of their own manufacturing strategy and production system according to Säfsten and Winroth (2002). The conditions between the SI and each network partner are then synchronized in a number of steps, see Figure 3.

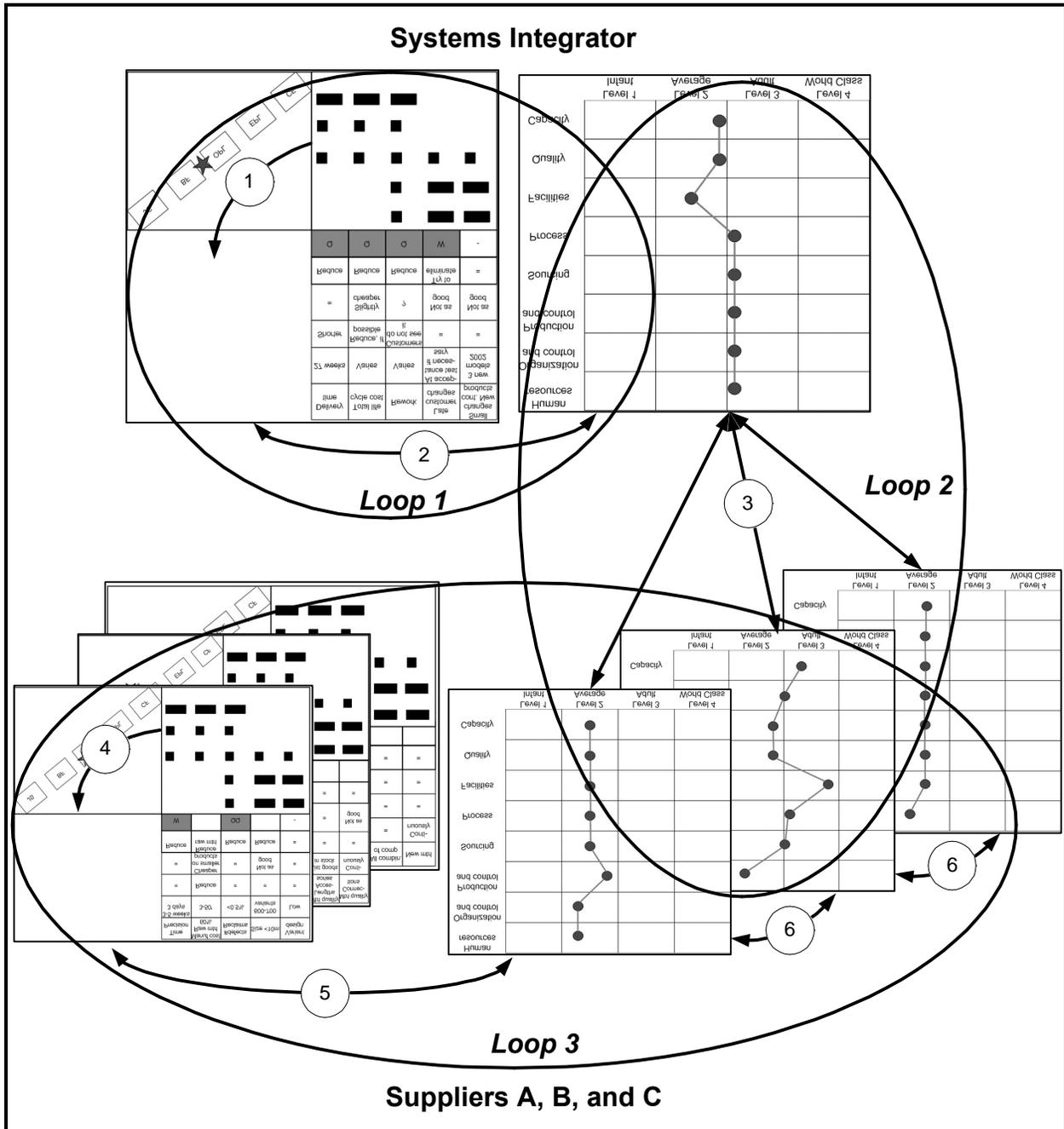


Figure 3. The proposed method for analyzing production systems and manufacturing strategies in collaborative network settings.

The steps of Figure 3 are:

1. The SI correlates its competitive priorities with its production system and detects suitable changes.
2. The SI performs an analysis of its strategic decision categories and makes suitable changes, either to the production system design or the decision categories.
3. The SI's strategic decision categories give input to the decision categories of Suppliers A, B, and C.
4. Each supplier correlates its competitive priorities with its production system and detects suitable changes.
5. Each supplier performs an analysis of its strategic decision categories and makes suitable changes, either to the production system design or the decision categories.
6. The suppliers coordinate their decision categories and take necessary actions.

In our analysis of linkages between manufacturing strategies and production system in a collaborative network setting we could identify three major processes, loops of information processing, developing a joint manufacturing strategy for the collaborative network and design of production systems within each company enabling manufacturing and delivery of complete products to final customer..

The first loop is a process mainly taking place at the systems integrator level (SI), involving steps 1 and 2 in Figure 3. As the leading actor in creating the network setting, the SI has to analyze the market situation and the customer requirements. In this process the present manufacturing systems influence the analysis of decisions areas, which is fed back to the design of the production system. In this case the new customer placed increased demands on the SI to deliver complete products, while the main share holders placed financial restrictions. This delicate situation of customer demands and financial restrictions is of course important strategic implications placing restrictions on SI actions to perform this new deal. This situation forced SI to look for another organizational solution to be capable of delivering complete products without increasing its own organization. The solution was to select few suppliers as their preferred suppliers. In addition to this, these preferred suppliers were asked to be collocated with SI. The reason was that SI had a vision of close collaboration with suppliers on the close range to enable intense communication and development of close relations between people in the supply chain. The choice of suppliers was guided by the old relations with suppliers as well as by decisions made on how to find suppliers with complementary manufacturing strategy and compatible and supportive production systems. The answer was that there were no suppliers fitting into the chart of new SI demands. Suppliers, willing to participate in this new competitive situation, had to be identified. The chosen suppliers had to develop a joint manufacturing strategy together with the SI and other suppliers.

The second loop is a process of synchronization between SI and preferred suppliers. This turned in our analysis to be a crucial process. In this synchronization, SI and its suppliers were able to communicate market situation and customer demands. Also, they were forced to negotiate how suppliers should organize their production systems according to what SI was capable of doing on its own and what part of the supplier organization should be relocated to SI area. In the beginning of this process not all suppliers did know much of each other. This synchronization process not only linked SI with suppliers but also linked suppliers with each other in a mutual

process of negotiating, learning, and developing trust in each other. All participants came to understand that the final success was not only a question of SI as the corporation fronting the customer, but rather a question for everybody. This synchronization process is what Westley (1990) calls the strategic dialogue.

This appeared to be important managerial aspects of creating prerequisites for handling the unpredictable, the unknown, and the insecure that always characterize development and manufacturing of complex products. Management at SI and its suppliers developed an opportunity to analyze the present situation according to the mission, goals, and restrictions not only within the SI but within each supplier and between them all as a system. When these aspects were discussed, management could mutually shape an appropriate strategy for conducting tasks out of common understanding and acceptance of conditions for this new situation. This process is labeled by Westley (1990) as strategic conversation and micro dynamics of inclusion. In addition, they can together design appropriate structures and processes. The subjectivity in the actor approach becomes a line of activities (Garnsey, 1992, 1993).

Even if this new complex situation with customer demands and financial restrictions is new to the SI and it creates high level of uncertainty, the complexity has some structure after all. The structure of a complex situation emerges when relations between SI and suppliers are communicated and depicted, made explicit, and the source and impact of these relations become clear to everyone in this network. The initial chaos of a complex situation is handled through communication events and through strategic conversation. This process enables the local knowledge to be transformed into global knowledge, stressing the understanding of the whole and not only knowledge from a particular functional perspective.

Management at SI initiated and discussed with suppliers about strategic issues of the new business deal according to overall goals, milestones, restrictions, and day-to-day activities as a means to support and maintain the dynamics of diverse social structures in collaborative manufacturing setting. This process is known as the micro dynamics of inclusion, which creates mutual understandings and feelings of not being a stranger. This process of strategic conversation may bring clarity to areas of authority and responsibility within each corporation as well as between them in the network setting.

The third loop is a process of adaptation on the supplier level within each preferred supplier and also mutual adjustments between suppliers. The second and the third loops are interrelated in the strategic dialogue. From the strategic dialogue each supplier comes to understand this new situation and demands relevant to them. They have to decide how to respond to the demands, what part to relocate, and how to develop new organizational routines to handle the daily life activities not only in their own corporation but within the entire network.

The traditional organizational design is top-down oriented, starting from the top management levels in each corporation and down the line of command through management-driven installation. This kind of organizational design is based on the assumption that management in each company have the best understanding and know the best solutions to the problems facing a company. Organizational design is traditionally based on management command and management control. In complex situations such as presented in this paper, this assumption is not correct. Management at the SI may understand the 'big picture', but they normally do not have such detailed information and knowledge about sub-systems and suppliers, and therefore they cannot in detail fully understand the complexity of situations. They are therefore not able to design appropriate corporate structures or processes on their own to handle this new situation,

without the considerable assistance of suppliers that are experts in their own areas and their own production systems. On the other hand, suppliers do not have the 'big picture' either. The perspectives of SI and suppliers are different and it is not an issue of whether SI or suppliers are more right than each other. It is a matter of combining different perspectives in the design of structures of the collaborative network and the processes that enables the collaboration between them in a network rather than on their own. Suppliers however, know much more on the detailed level, although they lack the information and knowledge of the whole, the goals and mission of the system integrator company or a specific project. Together, however, SI and its suppliers have a much more comprehensive picture of 'the world' than each of them have on their own and therefore they can through the strategic dialogue develop supportive manufacturing strategies and design supportive production systems within each supplier company as well as on the network level.

5 Conclusions

When this research was set up three leading hypothesis were stated. In this final part we connect our conclusions to our hypothesis.

Our first hypothesis is that manufacturing partnership between a systems integrator and its suppliers, on the business level, needs to have a supportive manufacturing strategy on the network level supported by manufacturing strategies on the corporate level in each company on the network.

In our research we found that when collaborative network was setup companies could not function well because they all had different manufacturing strategies. Collocation of suppliers forced them to develop a strategic dialogue about the market, customers' demands, goals of collaboration etc. This communication among all network participants enabled them to understand the prerequisites for collocation and how their new manufacturing systems had to be designed in order to support systems integrator. All of participants had to reevaluate their original manufacturing strategies and to adjust according to the dialogue.

Our second hypothesis is that high level of manufacturing integration between systems integrator and its suppliers, on the tactical or project level, needs to be supported by the design of production systems within each participating company enabling delivery of complete systems to customers.

In our research we found that this was a process that was a consequence of the strategic dialogue that took place in the early stage of collaboration and even long before the physical collocation took place. From our findings we conclude that it is important to establish, at an early stage, a dialogue between the systems integrator (SI) and its partners of a network with the purpose to analyze the conditions and possibilities for a close collaboration in manufacturing. The importance of an early start of this time and resource consuming process is that it should be possible to switch to other suppliers if necessary. The dialogue is strategic since it is based on the conditions of the SI and its manufacturing possibilities. Thus, the competitive situation of the SI is essential to the entire network.

Our third hypothesis is that synchronization of manufacturing strategies and production systems among companies within a collaborative network setting should be based on a shared view of the competitive situation that the systems integrator and its suppliers are facing as a collaborative network. This shared view enables these companies to adapt to environmental demands and changes in a flexible and rapid way.

In our study, the case is special since the SI demanded that the chosen suppliers should be collocated close to the SI. The suppliers had to be able of understanding the SI's competitive conditions and that their organizations had to adapt to the manufacturing situation of the SI. It also creates a possibility to make the new manufacturing maximally optimized to suite the collaborative network. This strong involvement of suppliers at the operative level called for mutual trust between the actors, since the suppliers are granted access to the SI's premises, where they can deliver components straight into the store.

A prerequisite is that the supplier continuously has access to good information about the market situation, customer conditions, and the order capacity, not only at the SI but also at the other partners of the network. A well developed computer-based information system infrastructure was found to be important if the suppliers will get necessary information early in order to make their own planning and manufacturing. This calls, on the other hand, for a transparent structure between the companies that enables information sharing. A prerequisite is that the partners have a well developed mutual trust and understanding.

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