Proceedings CINet 2002 Conference
September 15-18, 2002, Espoo, Finland, pp. 47-58.

THE CHALLENGE OF MAINTAINING NEW PRODUCT MANUFACTURABILITY CAPABILITY WHEN OUTSOURCING VOLUME MANUFACTURING

ANALYSIS OF A TELECOM COMPANY

LARS BENGTSSON, CAMILLA NISS, SUSANNE STJERNSTRÖM, STEFAN WESTIN

University of Gävle, S-801 76 Gävle, Sweden
lbn@hig.se

ABSTRACT

In this paper strategies for maintaining new product manufacturability (NPM) capability when outsourcing volume manufacturing are analysed. The analysis is based on a case study of a Swedish telecom company and discussed from two theoretical perspectives. The company has chosen to keep industrialisation of new products in house, in order to secure effective product design and NPM capability. The subsequent challenge of maintaining industrialisation capability, which is based on manufacturing competence, is discussed. Finally, the paper elaborates on a learning dilemma regarding the exploitation of internal industrialisation competencies, which contrasts with the accumulated learning expressed in standardised processes provided by contract manufacturers.

INTRODUCTION

Outsourcing has progressively become an explicit strategy commonly used by industrial companies to become more effective and competitive. The most common motives specified by managers are expectations of cost reduction and releasing resources. An emerging rationale for outsourcing is strategic, e.g., getting access to new competencies through alliances and faster product development (The Outsourcing Institute, 2001). The effects of outsourcing are, however, not clear. Particularly the long-term effects on the company's competence and innovative capacity are still an open question. Based on mainly theoretical analysis, researchers have suggested that outsourcing may be understood as a learning dilemma (e.g., John et al., 2001; Bengtsson, 2001); that is, that the potential of learning in networks contrasts and has to be weighted against the potential of internally exploiting closely integrated processes.

This learning dilemma is also relevant when outsourcing manufacturing. The strategy of outsourcing (non-core) components and systems to various subcontractors is well established. This strategy is also supported by numerous decision models about whether to make or buy (e.g., Wasner, 1999). A partly new trend within the telecom sector is to outsource volume manufacturing by making a cut in the product life cycle, i.e. that the product company focuses on product design while contract manufacturers take care of manufacturing. How this will affect the capabilities for product and process development is unclear.

The potential for learning from the specialised contract manufacturers partly seems to contrast with previous research on and experiences with product development processes. On the one hand, there are several studies that put forward the potential for learning in networks (e.g., Gadde & Håkansson, 2001; Håkansson et al., 1999; Quinn, 1999). As an example Quinn and Hilmer (1994) emphasise the importance of the interface between customers and suppliers. They refer to investigations proving that two-thirds of the innovations occur in that interface. On the other hand, several studies highlight the internal processes. Brown et al. (2000) conclude that the integration of design, marketing and manufacturing reduces costs and time-to-market, and that this integration is claimed to be more difficult to maintain when one of these functions is external. Brown (1996) also stresses the importance of integrating the phases of design and the industrialisation process, and furthermore working in cross-functional teams. Another way of putting this is proposed by Tidd, Bessant & Pavitt (2001) who believe that the innovation process depends on input in the product development process regarding the technological know-how in the firm and also the knowledge of how to manufacture the existing products.

The significance of production knowledge for efficient and rapid product development and renewal is verified by several studies (McDermott & Handfield, 2000; Brown et al., 2000; Swink, 1999; Susman & Dean, 1992). Swink (1999) concludes that production is essential for the ability to design new products and to obtain sufficient manufacturability in the solutions. The potential of manufacturing competence for product design as well as for judging potential suppliers has also been put forward. The significance for improving NPM (New product manufacturability) is also clearly indicated by the progress of concepts like DFM (Design for Manufacturing) and DFA (Design for Assembly). It seems, however, important to find proper ways of organising the integration and the intimate co-operation between product design and manufacturing. Otherwise, there is a risk that time for product development may increase with an increase in concern about NPM and DFM issues (see e.g. Kessler & Chakrabarti, 1999). The kind of knowledge, more specifically, that makes manufacturing competence of significant importance for efficient NPD and NPM is, however, more scarcely summarised in the literature. In our previous research we have discerned at least four main areas where manufacturing knowledge is of strategic importance (Bengtsson, 2001). The first area concerns an ability to *rationalise manufacturing* in terms of optimising existing resources and continuous improvements in technology and work methods. The second area concerns an ability to *make the procurement and sourcing process more effective*, which also includes an ability to judge the offers of potential suppliers. The third area concerns an ability to *secure product development competence* in terms of an ability to design for manufacturability. Finally, the fourth area concerns an ability to *ensure fast industrialisation and production ramp-up*, which requires cross-functional co-operation between various functions, such as product design, manufacturing technology, procurement and supply chain management.

One dilemma thus seems to be how to secure manufacturing competence and consequently manage manufacturability when outsourcing. So far there are few studies on how the links between different competencies in product development and manufacturing will be affected by outsourcing volume manufacturing.

The purpose of the paper is to analyse the challenges and the strategies to maintain new product manufacturability (NPM) capability when outsourcing volume manufacturing. The paper is based on an on-going case study within a Swedish telecom company. The strategies and the potential effects and challenges are analysed from two theoretical perspectives.

THEORETICAL FRAMEWORK

We have chosen to relate our analysis to two theoretical perspectives that can both be useful when considering activities inside or outside the firm: the concept of core competence (a resource-based view) and network theory. These two theoretical perspectives are not exclusive, rather complementary (Das & Teng, 2001).

The resource-based view provides a theoretical contrast to the environmental view, represented by Porter among others, which states that the competitiveness of the firm is first and foremost determined by the attractiveness of the industry and the positions achieved in the market. Building on the assumption that a firm's strategic resources may be heterogeneous and imperfectly mobile, the resource-based view of the firm can provide an explanation why a firm can outperform competitors under similar conditions. Barney (1991) argues that without these two basic assumptions, firm's cannot obtain sustained competitive advantages. Further, a resource must have four attributes to have the potential to be a sustained competitive advantage. Resources must be valuable, rare, imperfectly imitable and not substitutable. This is in line with the concept of core competence, presented by Prahalad and Hamel (1990). According to them, the roots of competitive advantages are the core competencies. These are cross-functional, non-physical assets made up of the collective learning in the firm, representing a deep systematic dependence within the organisation. The link between the core competencies and the end products is the core products, which are physical embodiments of core competencies. Important to understand is that the source of sustained competitive advantage need not necessarily be exclusively internal assets, it may also, as suggested by Barney (1991), be relations to other organisations.

Thus, from a core competence perspective, the firm not only needs to develop internal competencies, but also needs to develop strategies on how to co-ordinate and take advantage of the competencies and resources of other firms. A theoretical perspective that strongly emphasises the importance of considering both the internal and external resources when developing a firm's strategy and the importance of managing business relationships is network theory. While suggesting the importance for customers to take advantage of the external resources of suppliers, Gadde & Håkansson (2001, p.96) exemplify three ways in which suppliers are important. Firstly, they suggest that a supplier "may have important production resources that are complementary to the buying company's own production facilities". Secondly, they suggest that "the supplier may have knowledge and/or competence of vital importance for the buying company". Finally, they suggest that "suppliers may have relationships to counterparts who can also be important resource providers for the buying company". Thus, according to this kind of theory, to become a successful actor in a business network, in terms of being a "knowledge unit" (Gadde & Håkansson 2001), the knowledge does not necessary have to be internal; it may as well be activated by actors outside the firm.

Drawing from such network theory, Håkansson, Havila and Petersen (1999) suggest that organisations can learn in two ways – via their own experiences or through the experiences of other organisations. Based on a survey on how companies learn from other companies, they argue that the extent to which learning takes place "seems to be highly related to the existence of connections between the relationships", and that "the more each single relationship is a part of a network, the more the company on average seems to learn from it" (Ibid., p. 443).

METHODS

As briefly introduced, our analysis concerns how outsourcing volume manufacturing affects new product manufacturability capability. When separating design and manufacturing (as illustrated in Figure 1), the centre of attention moves to the process in between, i.e. the industrialisation process and its interfaces in terms of competence interrelationships. Two relationships are of special interest to us: The first is the link between design and industrialisation, and the other the link between industrialisation and volume manufacturing. Our main focus in this paper is the dependencies between competencies in the latter relationship (link 2 in Figure 1). The next step in the research process is to follow a design project and analyse in depth the connections between design and industrialisation (link 3) and design and volume manufacturing (link 1).

The case study presented in this paper concerns a telecom company that recently adopted an outsourcing strategy, that besides traditional outsourcing of non-core components comprises outsourcing of all volume production to various contract manufacturers. Thus, this case clearly relates to our main question of how outsourcing volume manufacturing will affect the new product manufacturability capability, given the traditionally intimate dependency between design and manufacturing.

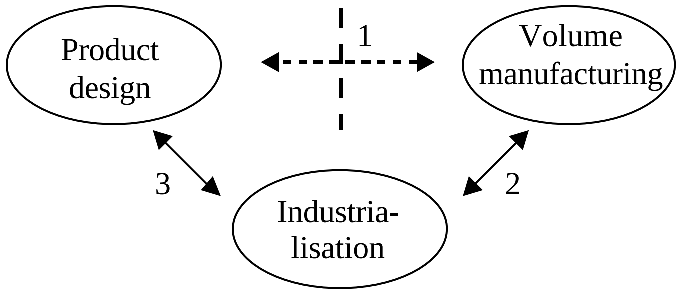

Figure 1. Analysis model

The case study has been conducted through open-ended, semi-structured, face-to-face interviews with a total of 10 people within the industrialisation unit at the telecom company. The interviewees include managers at different levels and for different functions, such as logistics, planning and operations, and business development. We have also conducted interviews with union representatives. The interviews took place during the spring of 2002. Since one of the authors of this paper has been employed at the company for over three years, and two of the others have conducted action research as well as case study research at the factory during 1999-2001, extensive knowledge about the company and its activities and processes served as a point of departure for the research group.

CASE STUDY

The company and its outsourcing strategy

The studied company is part of a global OEM corporation within the telecom industry that comprises several business areas. The focal company produces radio base stations (RBS). This network product includes a number of separate units with different functions. The main functionality of an RBS is built into the transceiver unit, i.e. the radio module, which is thus the core component of an RBS. Other units are include the power supply, climate system and antenna control. The centre for product design and development of the RBS is geographically separated from the production centre.

Less than ten years ago the company was more vertically integrated, and the internal manufacturing capacity was extensive. The manufacturing strategy was to have master plants, which performed the industrialisation of new products and continued to manufacture them as volumes grew. When the market expanded further and new products were introduced in parallel, there was a need for extended manufacturing capacity. To meet this situation, the product and the manufacturing concept were transferred to another corporate plant, supported by the master plant. However, in conjunction with this "internal outsourcing", the studied company has also successively outsourced more and more of its manufacturing of non-core components to various system and component suppliers.

Lately, the company has adopted a new outsourcing strategy. The strategy and the main processes during the product life cycle are illustrated in Figure 2. The production units have one by another been sold out to so-called various contract manufacturers, so-called EMS (Electronic Manufacturing Service) providers. The core competencies of the company are defined as: product design/development, test development and industrialisation of new products. The strategy implies a limitation to industrialisation of core components (radio modules) and the complete product (including final assembly and final tests). The remaining components and subsystems will be industrialised by external actors, and in some cases also externally designed. Volume manufacturing is thus no longer intended to be internally performed. The strategy could be described as a vertical cut in the product life cycle for core components.

The motives for this strategy are several. One explicit motive to keep the industrialisation process in house is that this process is regarded as particularly important for efficient product development and short time-to-market, which is crucial in an industry characterised by short product life cycles. Another motive is the expectation that global contract manufacturers may provide lower cost in volume manufacturing due to economies of scale based on their large customer base. Another motive could arguably be the prevailing financial situation of the company and the whole telecom industry.

The operations of the industrialisation plant

The previous master plant accordingly gets an even more pronounced role as an industrialisation plant. This plant has about 1400 employees. Its main process and task is thus to make the products producible and secure the supply chain. Initially this includes close co-operation with the units responsible for product design. After the early stages of continual product and process development, including prototype and pilot production, manufacturing is ramped up to high volume. The industrialisation plant considers having the capacity for full scale manufacturing for each product during a short time (NPI-volume). During the end of the industrialisation process a final selection of contract manufacturer is made. Thereafter, a specific transfer project (TPI, Transfer Product Introduction) is set up. The TPI project aims at transferring knowledge about products and manufacturing, as well as product-specific technology and test equipment, to the chosen EMS that carries out volume manufacturing. Beyond this there is an ambition to create the necessary conditions for design to be able to gain experience from different actors and activities during the whole product life cycle, in order to enhance future products.

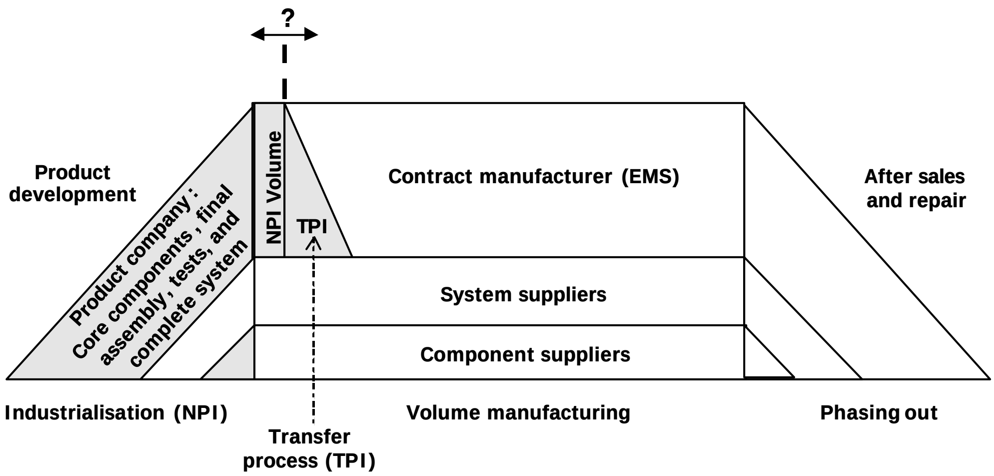

Figure 2. The product life cycle, illustrating the main processes and outsourcing strategy of the studied company.

The outsourcing strategy puts industrialisation in focus. Following the new strategy, an important and challenging task for the company is to keep and develop NPM capability. Due to its role as industrialisation unit, the studied plant has an important part in this task. The needed measures to successfully cope with these obligations are seen as recurrent activities, thus treated as a process. This process is a stabilising counterbalance to the ever-changing environment with regard to the product line. Hence, the company has developed a generic process for the introduction of new products. It defines NPI (New Product Introduction) as *"…the term used to denote all activities in a product development project – from assignment to achieved project targets (Time, Quality and Cost) – that are intended to assure production capacity, producibility and the ability to deliver market volumes at the right time, at optimised cost (LCC) with minimal environmental impact."*

Four functions are included in the NPI process: marketing and sales, product design, services and support and finally supply, which includes sourcing, production, distribution and operations (planning, order and installation). The model clearly indicates that the representatives from these functions should work together in cross-functional teams. By organising the process this way, it is expected that several problems can be eliminated, such as the design ending up at a level dangerously close to the limits of production capabilities or the product design not being appropriate for an efficient supply chain.

The generic process consists of four main phases. These are:

- The concept phase. The best proposal as to how to supply the product is developed, and the competence needed for the project is acquired. A map that will guide the rest of the project is created.
- The establishment and specification phase. The project team and resources needed are specified in detail. It is decided how the product can perform its allotted tasks, and clarified how production volume is going to be achieved. When this phase is finished, everything is set for the prototype phase.
- The design and learning phase. Here the functions and processes are developed, and the supply chain is being trained in these processes and the product. This requires several iterations until it can be verified that the right level is achieved.
- The verification and follow-up phase is a time-consuming phase. It is a time to check whether everything has been successfully accomplished so far. Pilot production is started and production is ramped up. This is as much a trial for evaluating the product as a chance to verify the supply chain. Finally, remaining problems are followed up and rationalisation measures are taken to reduce time to break even and experience is summarised in order to benefit future projects. At the end of this phase, the product is ready to be transferred to external suppliers.

Choices when realising the outsourcing strategy

The strategy shift is an ongoing process. It has so far only been partially realised for two products, both being low-volume subsidiary products. But the strategy is intended to be extensively applied for the next product generation, which was recently introduced. Resources have also been reallocated from manufacturing to product development projects and supporting training programs are running.

There is an on-going debate about how to realise the chosen strategy internally. One discussion concerns how to secure industrialisation competence in the long run when outsourcing volume manufacturing. The expressed strategy and the generic NPI process more strongly emphasise the link between design and industrialisation (link 3 in Figure 1), than the link between industrialisation and volume manufacturing (link 2). There are however some concerns about this focus. Typically, the sourcing manager states that: *"today we know very well how to produce the products cost-effectively with good quality. But how will this affect our competence for industrialisation in the long run? And furthermore, how will we be able to judge and select among suppliers if we don't have this ability ourselves anymore?"* He furthermore stresses the significance of manufacturing competence: *"Manufacturing competence is a basis for efficient industrialisation of new products. Industrialisation requires intimate co-operation between design and production, both when it comes to production of prototypes and pilot products and rapid ramp-up to volume production. Flexibility in manufacturing is also crucial for managing rapid product changes."*

Another discussion concerns how to co-operate with contract manufacturers. In principle, as clearly expressed in the generic NPI model, the company stresses early and intimate co-operation with all suppliers. In practice, this is mainly valid for internal suppliers and system suppliers involved in the design process. The actors who later will take on the responsibility for volume manufacturing are not given the same, explicit, important role. A dominant conception among those responsible for industrialisation concerns whether or not the company has sufficient competence in order to effectively industrialise the product and create an adequate supply chain. This implies that a designed “package” is handed over to an EMS company, whose core competence is to manage this “package” in the most efficient way, but not to design it. In line with this thinking the company most often doesn’t choose the EMS from the beginning of the NPI process, but rather keeps two sourcing alternatives open during the entire process. However, when transferring the responsibility for manufacturing, the product and processes are not completely ready. Experiences from the transfer projects show that besides a lot of product revisions there is a need of continuous process changes in order to reduce costs and improve quality.

A third discussion concerns whether the studied industrialisation unit should keep some capacity for volume manufacturing or not. The corporate view is that all volume manufacturing should be outsourced to contract manufacturers. What this really means is, however, not quite clear. The master planner claims that: “*In order to debug the product completely, it is necessary to run volume manufacturing*”. Furthermore, where to put the vertical cut could also vary, due to the pace in product renewal. In order to secure full capacity for industrialisation of new products and at the same time have a reasonable capacity utilisation in the plant, the transfer of manufacturing may occur sooner or later, which is illustrated as a vertical dotted line in Figure 2. This means that keeping some manufacturing in house provides flexibility to fill up the capacity of the plant. Or as the master planner puts it: “*We would rather manufacture than play pool*”.

DISCUSSION

Strategy for maintaining NPM capability when outsourcing volume manufacturing

Our main question in this paper concerns how to maintain NPM capability when outsourcing volume manufacturing.

In this case, the company has chosen to maintain the industrialisation of certain core components, tests and final assembly in house when outsourcing volume manufacturing. There are several reasons for this strategy. One main reason is that product complexity as well as unstable products and manufacturing processes stress the need for intimate co-operation between product design and manufacturing technique. Non-core components are outsourced, since they are regarded to be less significant for the competition on front-line functionality. By keeping the industrialisation of the most essential components in house, the company tries to maintain the necessary feedback mechanism between manufacturing and product development internally. This is in line with the literature on NPD and NPM, which has clearly shown the value of integrating manufacturing aspects when developing new products (e.g., Swink, 1999; Brown et al., 2000).

To collect evidence on the long-term effects of the chosen strategy requires a longitudinal study, which is in progress. In the present situation we may, however, conduct a theoretical analysis of the potential effects of the strategy of outsourcing volume manufacturing and maintaining the industrialisation of new products in house. The company explicitly describes their strategy in terms of core and non-core components and processes. In this case, the most important functionality of a radio base station (RBS), is determined by the radio modules. The radio modules may thus be considered what Prahalad & Hamel (1990) call a core product, meaning that excellence in developing these modules is assumed to boost the core competence of the company. From the company’s point of view, the outsourcing of non-core components and processes will free up resources for developing core processes. However, whether there is a systemic interdependence between the defined core and non-core processes is still an open question.

The case company has furthermore chosen to keep the industrialisation of the complete RBS and the final assembly in house. One motive is that final assembly provides a natural interface to the customers and this interface supports internal ownership of problems that occur. Another motive put forward is consistent with the systemic nature of core competencies, i.e. that there are dependencies among various competencies. An internal industrialisation of final assembly aims at ensuring system engineering competence, which is of value both for the next product generation and for preventing product degeneration downstream when outsourcing volume manufacturing. The systemic perspective is also in line with the findings of Fine & Whitney (1999, p.40).

Conclusively, the case shows that a possible strategy to maintain NPM capability when outsourcing volume manufacturing is to keep industrialisation of specific core components in house. The strategy also supports the systemic perspective of core competencies, which may have positive effects on long-term competitiveness. To maintain and nurture industrialisation competence thus seems to be crucial for maintaining an efficient NPM capability within the company. Furthermore, the case supports the initially stated conception that design and manufacturing are to some extent intimately related processes.

Strategy for maintaining industrialisation capability: The significance of manufacturing competence

If in-house industrialisation is one possible way to preserve NPM capability, a remaining question is how to maintain industrialisation competence, which is a production-related knowledge, over time, when outsourcing all volume manufacturing. The individuals and the organisation still have a lot of knowledge of and experiences with manufacturing within the company, since the new strategy has just recently been implemented. But what will happen in the long run?

There are no clear answers in the literature regarding this specific outsourcing strategy. Most literature on outsourcing focuses on component-based outsourcing, which in this case is valid for the non-core components. The outsourcing in focus is rather a kind of process-based outsourcing, specifically characterised by a cut in the product life cycle. But, one way to further discuss the question is to look closer at the specific demands on the NPI process, and theoretically analyse how the changes in these demands, due to outsourcing, could be handled in the long run.

The main objectives of the company's definition of the NPI process could be interpreted as traditional demands on the industrialisation process:

- To make sure that the product is producible according to the technical specifications.
- To assure production capacity and ability to deliver market volumes at the right time. These demands include building up and securing the capacity of the supply chain by engaging different suppliers.
- To optimise processes for sufficient quality and cost-efficient volume manufacturing.

When outsourcing volume manufacturing, two new demands could potentially be added:

- To absorb manufacturing knowledge for future design and sourcing decisions. This could be interpreted as a kind of feed-forward mechanism.
- To organise an efficient transfer to the contract manufacturer.

Most of these tasks require manufacturing knowledge and experience. When outsourcing, the traditional demands on manufacturability, efficient procurement and continuous rationalisations still remain (Bengtsson, 2001). The new demands indicate a need for learning and more intimate co-operation with subcontractors. This could maybe be realised during the TPI process. Our previous research shows that the transfer process is not a simple process of teaching the subcontractors, but should rather be regarded as a mutual learning process (Niss, 2002). However, absorbing knowledge from suppliers is probably more difficult when not having experience from own manufacturing (compare Veugelers & Cassiman, 1999). It may also be problematic for the industrialisation unit to maintain knowledge about optimising manufacturing for costs and quality without running it at full scale. The final demand indicates that it is important to integrate the transfer process with the industrialisation process and, furthermore, to involve the subcontractors at an early stage. Briefly put, the analysis indicates that industrialisation capability is based on a cross-functional combination of competencies, inherited in manufacturing technology and tests, in production logistics and procurement and in supply chain management. To obtain effective co-operation takes time, and is possibly facilitated by having in-house production, which has been stressed by Brown (1996), as well.

This means that there are, theoretically, two opposite alternatives available to maintain industrialisation capability in the long run. One is to consciously and systematically organise for mutual learning and innovation in the relationships with external actors, such as suppliers. However, according to Gadde & Håkansson's (2001) findings, such learning has to be facilitated. Learning does not "just happen", but needs to be organised. This is in line with Das & Teng (2000) who from an RBV on strategic alliances believe that it is also necessary to focus on internal resources and the environment of the partner firm in order to match or pool complementary competencies. The outsourcing of volume manufacturing means, in fact, the creation of a new relationship between buyer and supplier. In this case, however, the learning opportunities based on the EMS company's knowledge are not used in a systematic way. The case company, so far, regards their own manufacturing knowledge as sufficient.

The other alternative is to maintain manufacturing in house, which is in accordance with the systemic nature of core competence. The company in our case has chosen a strategy more like the second alternative, since the company anticipates cost reduction rather than learning from the EMS companies. This alternative, as mentioned earlier, is to maintain volume manufacturing of core components and final assembly in house for a short time and outsource the rest. Since the extent of this internal and complementary manufacturing process (called NPI-volume) also depends on the pace of new product introduction, it could be interpreted both as a "capacity regulator" and as a "strategic source for manufacturing knowledge".

Whether the manufacturing competence may be sufficiently retained when manufacturing a product only for a short time, is an open question. This is especially unclear since the company's experience is that revisions of products and rationalisation of processes take place during the entire product life cycle. But, if so, this would not least help to maximise the utilisation of upstream component suppliers. It is likely that the company will increase their capability to suggest and judge possible improvements in the supplier's products.

Remaining learning dilemmas when outsourcing volume manufacturing

Outsourcing volume manufacturing implies possible dilemmas. More generally, this dilemma could be described as the trade-off between exploiting the internal production-related core competencies and the possibility of learning in networks. This dilemma is relevant whenever deciding whether to outsource or not, but also in this particular case. In this case the telecom company has defined its core competencies, industrialisation being one of them. Hence, from a core competence view, it makes sense to internally perform and keep control of this activity, as it is intimately associated with the creation of sustained competitive advantage. However, from a networks theory perspective, there should be great potential in the relation between the volume manufacturer, the EMS provider, and the telecom company.

This dilemma is, in this case, highly dependent on the chosen level of volume manufacturing before outsourcing, the so-called NPI-volume. The higher volume manufactured before outsourcing, the greater the learning possibilities, and hence better feedback to the process and product design. As stated by one interviewee in the case study: "*In order to debug the product completely, it is necessary to run volume manufacturing*". Of course, the higher volumes manufactured, the greater the possibilities to maintain manufacturing knowledge as a core competence. However, the implications of a high NPI-volume could possibly be less cost efficient, since the manufacturing process of the industrialisation plant is not exclusively dedicated to full-scale production. It is likely that at high volume, the cost per unit is relatively high. Another important downside to a high NPI-volume is the need for a repeated industrialisation process. With the present strategy, the industrialisation process is not fully adjusted to the EMS company. In order to use the potential cost benefits of large-scale manufacturing, the industrialisation process ought to be adjusted to the standardised processes of the chosen EMS provider (compare the reasoning of Das & Teng, 2000). In our case company, there are so far no such efforts. This means in practice that there will be two industrialisation processes, one internally aiming at designing for manufacturability, and another during the transfer process aiming at adjusting processes to EMS companies and optimising the manufacturing process in terms of costs. These two processes overlap, and thus cause costly redundancy. In our previous research we have also found that the transfer process itself is a problem. The transfer process is usually regarded as a more or less complex transfer of equipment and knowledge. But, since the EMS company has its own work processes, it would be more convenient to understand the transfer projects as arenas for dialogue and mutual learning (Niss, 2002).

The problem can also be described in terms of controlling "what" or "how" in manufacturing (Quinn, 1999). Depending on the product company's design and NPI process, how to manufacture will be more or less determined for the EMS company. It is, however, reasonable to believe that the higher the NPI-volume, the more specified the manufacturing process, i.e., more specified "how". According to network theory (Gadde & Håkansson, 2001), the more specified the manufacturing process, which limits the "how" of the supplier, the less might be the possibility for the supplier to standardise activities, meaning using the same resources for different kinds of activities for different customers. Thus, the more the buyer specifies how to manufacture, the less will be the possibilities for innovation at the supplier (Quinn, 1999) and the less use will the buying firm have from the fact that the supplier can learn from its relationships with other buyers. The choice of keeping the NPI-volume internally, based on capacity and competence motives, does not solve this dilemma. On the contrary, this might only increase the control of how to manufacture. On the other hand, only specifying "what" to manufacture, which to a greater extent might be the result of a low NPI-volume, will possibly lead to an increased use of standardised processes in order to enhance the economics of scale of the supplier. However, there might be a risk that this negatively affects NPM capability, since it requires mutual adaptation ability.

CONCLUSIONS

The analysis shows that outsourcing volume manufacturing makes the question of how to maintain new product manufacturability capability within the product company critical. This challenge needs to be handled within the industrialisation process, i.e. the process between product design and manufacturing.

NPM as well as NPD capability is, as stated in the literature, to some degree dependent on the interaction between manufacturing and design. When outsourcing volume manufacturing, the company in this case has chosen to maintain the industrialisation of certain core components, tests and final assembly in house. A main motive for this strategy of keeping the industrialisation of the most essential components in house is that the company tries to maintain the necessary feedback mechanism between manufacturing and product development internally. It thus seems reasonable to keep and nurture the internal industrialisation process, since it is crucial for maintaining an efficient

NPM capability. The analysis furthermore supports previously stated conceptions in the literature that design and manufacturing are not easily separable processes.

A further question regarding preserving NPM capability is how to maintain industrialisation competence over time when outsourcing all volume manufacturing. Our analysis indicates that industrialisation capability is based on a cross-functional combination of competencies, rooted in manufacturing knowledge and experiences and in logistics, procurement and supply chain management. The demands on industrialisation could traditionally be described in terms of improving manufacturability, organising and securing an efficient supply chain, and continuous rationalisation aiming at reducing costs and higher quality. When outsourcing volume manufacturing two potentially new demands could be added. These are mainly about organising an efficient transfer of the product, and absorbing manufacturing knowledge from suppliers, which is a kind of feed-forward mechanism of importance for future design and sourcing decisions. All of these tasks require some extent of manufacturing knowledge.

Hence, an important question following this strategy is how to maintain manufacturing competence. According to theory, there are two possible alternatives to handle this. One is to systematically organise and facilitate mutual learning and innovation in the interface with suppliers. The other alternative, which is in accordance with the systemic nature of core competence, is to maintain manufacturing in house. The company has chosen a strategy more similar to the second alternative, and its complementary manufacturing process (NPI-volume) could be seen as a “capacity regulator” and as a “strategic source for manufacturing knowledge”.

This choice creates a remaining learning dilemma, which could possibly be understood as a balance between the exploitation of internal presumptive sources of competitive advantages and the potential of learning from the network. The company has mainly chosen the former alternative, as it performs manufacturing of core components, even though only for a restricted time for each product. The dilemma is made visible by the chosen volume of internal manufacturing. The resulting advantages of a relatively high so-called NPI-volume are mainly the core competence enhancement and the innovative flexibility originating in the independence of the EMS provider’s standardised processes. However, one downside is the implicated double industrialisation, first internally and then externally to fit the manufacturing process of the EMS provider. Potential advantages with a lower volume would be potential network-based learning possibilities and the full exploitation of the EMS provider’s innovative capability. A disadvantage with this alternative could be limited innovation at the company due to the EMS provider’s wish to standardise the processes. Shortly put, the learning dilemma regards a conflict between the need to exploit internal industrialisation competencies and the utilisation of accumulated learning expressed in standardised processes provided by contract manufacturers.

REFERENCES

BARNEY, J.B. 1991. Firm resources and sustained competitive advantage. *Journal of Management*, 17, p. 99-120.

BENGTSSON, L. 2001. Outsourcing Manufacturing - An analysis of a learning dilemma. *Proceedings of the 4th International QMOD Conference*, 12-14 September, 2001, Linköping, Sweden, p. 424-433.

BROWN, S. 1996. *Strategic Manufacturing for Competitive Advantage*. Hertfordshire: Prentice hall Europé.

BROWN, S., LAMMING, R., BESSANT, J. & JONES, P. 2000. *Strategic Operations Management*. Oxford: Butterworth-Heinemann.

DAS, T.K. & TENG, B-S. 2000. A Resource-Based Theory of Strategic Alliances. *Journal of Management*, 26, 1, p. 31-61.

FINE, C.H. & WHITNEY, D.E. 1999. Is the make-buy decision process a core competence? *Logistics in the information age,* 4^{th} ISL, Florence, Italy.

GADDE & HÅKANSSON, H. 2001. *Supply Network Strategies*. John Wiley & Sons Ltd

HÅKANSSON, H. HAVILA, V. & PEDERSEN, A.C. 1999. Learning in Networks. *Industrial Marketing Management*, 28, pp 443-452.

JOHN, C.H., CANNON, A. & POUDER, R. 2001. Change Drivers in the new millennium: implications for manufacturing strategy research. *Journal of Operations Management*, 19, p. 143-160.

KESSLER, E.H. & CHAKRABARTI, A.K. 1999. Speeding up the Pace of New Product Development. *Journal of Production Innovation Management*, 16, p. 231-247.

McDERMOT, C. & HANDFIELD, R. 2000. Concurrent Development and Strategic Outsourcing: Do the Rules Change in Breakthrough Innovation? *The Journal of High Technology Management Research*, 11, 1, p. 35-37.

NISS, C. 2002. *Knowledge Brokering across the Boundaries of Organisations. An Interactionist Interpretation of a Temporary "Mirror-organisation"*. Stockholm: Royal Institute of Technology, KTH.

PRAHALAD, C.K. & HAMEL, G. 1990. The Core Competence of the Corporation. *Harvard Business Review,* May/ June.

QUINN, J.B. & HILMER, F. 1994. Strategic Outsourcing. *Sloan Management Review,* Summer 1994.

QUINN, J.B. 1999. Strategic Outsourcing: Leveraging Knowledge Capabilities. *Sloan Management Review,* Summer, p. 9-21.

SUSMAN, G.I. & DEAN, J.W. Jr. 1992. Development of a model for predicting design for manufacturability effectiveness. In Susman, G. (Ed.). *Integrating Design and Manufacturing for Competitive Advantage*. New York: Oxford University Press, p. 207-227.

SWINK, M. 1999. Threats to new product manufacturability and the effects of development team integration processes. *Journal of Operations Management*, 17, p. 691-709.

THE OUTSOURCING INSTITUTE. 2001. *Executive Survey. The Outsourcing Institute´s Annual Survey of Outsourcing End Users*. http://www.outsourcing.com. Access 2001-02-09.

TIDD, J., BESSANT, J. & PAVITT, K. 2001. *Managing Innovation, Integrating Technological, Market and Organizational Change*. Chichester: John Wiley & Sons Ltd.

WASNER, R. 1999. *The Process of Outsourcing - Strategies and Operational Realities*. Linköping: School of Engineering at Linköping University.

VEUGELERS, R. & CASSIMAN, B. 1999. Make or buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy*, 28, p. 63-80.