New product development : shifting suppliers into gear

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Ferrie van Echtelt

Technische Universiteit Eindhoven

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PROEFSCHRIFT

ter verkrijging van de graad van doctor
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voor een commissie aangewezen door het College voor Promoties in het openbaar te
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Ferrie van Echtelt,

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'To gain competitive advantage from outsourcing, managers should not ask what your supplier can do for you; ask what you can do with suppliers' (Takeishi, 2001)

1.1 Introduction

This PhD study investigates the way in which inter-company collaboration, and specifically vertical collaboration between a manufacturer and its supplier, can strengthen a company's capability to develop new products. Product development has become an important vehicle in developing or maintaining a strong position in an increasingly competitive business arena (Cooper and Kleinschmidt, 1987; Schoonhoven et al., 1990; Gupta and Wilemon, 1990; Eisenhardt and Brown, 1995; Smith and Reinertsen, 1998); its importance is still growing. However, the demands on product development performance, in terms of speed, performance and cost, are becoming more difficult to meet. Different 'recipes' are being tried and investigated, including more concurrent and collaborative forms of product development that allow outsiders to get involved in the company's product development process. Earlier and more extensive involvement of suppliers in product development is argued to help improve product development performance in terms of productivity, speed and product quality (Clark, 1989; McGinnis and Vallopra, 1998; Ragatz, et al. 2002; Primo and Amundson, 2002) and could be a source of innovative ideas (Håkansson, 1987) and critical technologies (Bonaccorsi, 1994). Suppliers in cutting-edge industries are considered to be the hotbed of innovation (Nishiguchi and Ikeda, 1996). However, involving suppliers does not *automatically* lead to improved performance (Birou, 1994; Hartley, 1997).

The aim of this study is to improve our understanding of what the critical processes are for managing the involvement of suppliers to lead to improved performance in product development. In this first chapter we will look at why supplier involvement in product development has become such an interesting phenomenon. We therefore discuss several trends in business to identify the drivers and rationale that support supplier involvement in product development as a relevant strategy. This is followed by a discussion of the main shortcomings of earlier research, which enables us to define the problem statement and the research questions. Finally, the design of the research indicates how the research was set up and carried out to answer the research questions.

1.2 Salient forces driving product development and supplier involvement

Since we are focusing on product development and the involvement of suppliers, we need to understand the salient forces that make product development such a critical business process. These forces in themselves present several challenges for the process of product development and for the achievement of the performance improvements. Companies face a particular challenge to co-ordinate their processes to meet the degree of customisation and to address the increasing technical product complexity. Moreover, performance levels are being raised to develop higher quality products and significantly faster than in the past and than those of the competition. This places increasing financial risks on individual companies. We will examine these forces and challenges in more depth in the following two subsections.

1.2.1 Increasing importance of product development

Product development has become an important business process that helps to strengthen and maintain a strong competitive position (Wheelwright and Clark, 1992; Brown and Eisenhardt, 1995). An indication of its importance is the significant proportion of sales coming from new products introduced recently on the market. Between 1994 and 1996, an average of 42% of the turnover of European companies came from new or improved products introduced on the market (Eurostat, 2000). Furthermore, R&D expenditure increased steadily in the last decade (from 1990 to 1998), with an average annual growth of 1.3% for European companies, 3.2% for US companies and 1.3% for Japanese companies (Eurostat, 2000). Basically, two major forces increase the importance of product development for companies: increasing customer requirements and intensifying competition.

Wheelwright and Clark (1992) state that consumers are becoming more sophisticated and are demanding customised products that are more closely targeted to their needs. They have become sensitive to life-style products that fit their finer personal tastes and that have raised their expectations regarding product (including service) performance. This trend has been partially influenced by technological developments in areas such as material science, electronics, computer and information technology and biotechnology. They have provided a growing breadth and depth of technological and scientific knowledge, and new options for creating and meeting the existing needs of customers.

Increasing competition is making product development an essential activity for companies. Product development is the vehicle through which they can partially differentiate their value offerings from competitors. Advances in Information and Communication Technology (ICT), internationalisation and trade deregulation have all spurred competition. ICT has allowed information about the latest products to reach the intended user or purchaser faster, which promotes an earlier switch away from the existing product. Moreover, the developments in ICT have specifically promoted the faster exchange of relevant information during product development, thus speeding up the introduction of new products. This has also resulted in increased competition in old and new markets. Competition has increased partially through the formation of trade regions such as NAFTA, EU and ASEAN, which have enabled companies to move closer to the customer and create access to previously inaccessible markets.

1.2.2 Changing product development process and performance demands

As the importance of product development grows, so do the demands put on the product development process and performance levels. These demands represent challenges for companies, who need to rethink the ways they try to meet them.

The first challenge concerns the need for companies to deal with increased product complexity when developing new products. Complexity is partially related to the technical content of the products. This complexity is particularly fuelled by the variety and speed at which new technologies emerge and need to be integrated in the development process. They create a challenge for companies to keep up their knowledge base and to have sufficient financial resources available to invest in various changing technological areas. In addition to the increasing technical complexity of products, the diversity and the variety of products in the market place are also growing (Goldhar et al., 1991). This increased variety of products to be developed and manufactured poses a co-ordination challenge for product development processes, and requires flexible manufacturing and logistics processes.

An additional challenge that companies face concerns the pressure to develop products substantially faster whilst improving their performance-cost ratios. The resulting time pressure is accompanied by substantial financial risks. The cost of arriving too late in the market can be enormous (Stalk and Hout, 1990). Both intensifying competition and changing customer demands reduce the commercial product lifecycle, and therefore limit the period during which companies can earn back their investment. Early market entry is critical if a company is to maximise the time window during which profits can be reaped. If it fails to speed up product development it may miss the boat and possibly end up bankrupt. In this changing landscape, we argue that the phenomenon of supplier involvement has emerged from, and co-evolved with, at least three strategic responses to deal with the aforementioned challenges.

1.3 Companies' strategic responses to product development challenges

In response to these aforementioned challenges companies are being forced to develop and implement new strategies and ways to organise their product development function. Over the past few decades we have witnessed at least three major, important, strategic and organisational responses: (1) outsourcing, (2) concurrent development and (3) inter-company collaboration. These responses provide the context in which we can understand the increasing role of suppliers in product development in some industries. Although their co-evolution means that they partially overlap and reinforce each other, they differ in their underlying motives. To gain a more comprehensive understanding of the emergent practice of supplier involvement in product development, we therefore consider them both separately and jointly.

1.3.1 Strategic response I: Outsourcing

The first response to address the product development demands is the move towards outsourcing activities that are not critical in achieving a competitive advantage in certain markets. This concentrates the company's own resources on a limited number of activities aimed at reinforcing their core competencies (Prahalad and Hamel, 1990). The core competencies idea was introduced to better understand the source of competitive advantage. A competitive advantage is derived from a unique combination of activities, capabilities and resources, enabling improved customer service and increased competitiveness. The underlying rationale is that companies will benefit more from specialisation if they choose to only carry out those activities in which they excel internally and which are critical for achieving competitive advantage (Prahalad and Hamel, 1990, Venkatesan, 1992; Quinn and Hilmer, 1994). For example, companies would have more financial and human resources available for product development if they could outsource activities such as non-critical assembly, production or logistics to more specialised and capable external parties, i.e. suppliers.

Outsourcing has had a major impact on the increased financial dependence of companies on suppliers. This dependency can be measured by the share of the costs of purchased goods and services in the total manufacturing cost. O'Neal (1993) demonstrated that, during the 1980s, US manufacturers were already quite dependent on their suppliers, with the value of purchased materials ranging from 30% to 80%. For example, Xerox already sourced 67.5% of its added value externally from suppliers (O'Neal, 1993, Steven Tierney, 1986). Nishiguchi (1994;97) reported a growth in outsourcing levels for the 10 largest Japanese automotive manufacturers from 66% to approximately 75% between 1961 and 1986. Other publications in the 1990s reported that this trend continued. In various industries, such as manufacturing and retail industries, the purchasing share in the cost of goods sold is reported to exceed 50%, and can even be as high as 80% (Handfield, 1999; Van Weele, 2000). Mol (2002) demonstrates that Dutch industry arrived at an average purchasing share[1] of 49% in 1998. A US study published in Purchasing (1999) pointed to similar ratios (see Table 1.1). However, it is important to note that suppliers are not equally important across industries, given the large variation in the extent of outsourcing observed. Nevertheless, the increasing importance of suppliers is hard to deny. These statistics indicate that companies, in controlling and improving their cost position, are increasingly dependent on the costs and profits of their upstream suppliers. In addition to the cost dependency, the purchasing ratios also point to the dependence of a manufacturer on its key suppliers for product quality and cycle time. As pointed out by Crosby, it was estimated that approximately 50% of a manufacturer's cost of quality is attributable to purchased materials (O'Neal, 1993 quoting Celley and Klegg, 1987).

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[1] Using a slightly different ratio, taking the Purchasing as a percentage of total yearly sales

The outsourcing trend has changed the job definition of suppliers to include more production, assembly and logistics activities. Many manufacturing companies that were trying to adopt the total quality management philosophy and its accompanying techniques, introduced by quality gurus such Deming, Juran, Takeuchi, Ishikawa and Crosby, started to extend them to their suppliers as well. This meant that the collaboration between the manufacturer and suppliers primarily focused on continuous quality improvement in production, assembly and logistics operations. Specific techniques including Failure Mode and Effects Analysis, Statistical Process Control, KanBan and Just-In-Time delivery were implemented to reduce wastage and cut the costs of quality in production and assembly in a supply chain. This initially enabled Japanese companies to achieve better product quality, lower product costs and a greater production flexibility to accommodate demand variations.

Table 1.1 The extent of outsourcing in US Industries. (Purchasing 1999; 52)

High level of outsourcing	% of cost of goods sold	Low level of outsourcing	% of cost of goods sold
Textiles	62	Utilities, gas and electricity	17
Transportation equipment	62	Petroleum refining	21
Motor vehicles and parts	61	Food manufacturing	38
Furniture	60	Airlines	40
Pipelines	60	Rubber and plastic products	41
Metal products	59	Mail, packaging, freight delivery	41
Chemicals	57	Railroads	42
Industrial and farm equipment	57	Building materials, glass	43
Engineering, construction	56	Electronics, electrical equipment	44
Metals	56	Pharmaceuticals	44
Scientific, photographic, control equipment	54	Telecommunications	40
Computer peripherals	52	Mining, crude-oil production	46
Soaps, cosmetics	50	Network communications	47
Computers, office equipment	50	Forest and paper products	48
Aerospace	50	Semiconductors	48
Waste management	50	Medical products & equipment	49

During the 1980s, manufacturers in the automotive and electronics industries increasingly started to rely on suppliers for design, testing and component procurement activities. This phenomenon was particularly visible at several Japanese manufacturers (Asanuma, 1989; Womack, Jones and Roos, 1990; Lamming, 1993; Nishiguchi, 1994; Helper 1996). Suppliers were increasingly being asked to optimise the design of a component to improve its manufacturability, resulting in improved quality and lower manufacturing time and costs. This involvement increasingly occurred during the earlier stages of the overall development process. In this way, outsourcing evolved into a trend towards the greater involvement of suppliers in the product development processes of their customers. Nishiguchi (1994) provides data on the proliferation of joint design projects between Japanese suppliers and their customers. During the 1980s, approximately 60% of the suppliers in Japan's electronics, transportation equipment and precision machinery industries were involved in their customers' design process

(Nishiguchi, 1994). Although it is the Japanese manufacturing companies that are well-known for their close collaboration with suppliers in product development, similar initiatives were started by US and European car manufacturers (Lamming, 1993; Dyer, 1996), allowing increased supplier responsibility for developing subsystems and components. However, it does not look like this trend will stay confined to the car industry. In a study of US manufacturers, Handfield et al. (1999) indicated that managers from other industries also expected supplier involvement in product development to become significantly more important in the future.

Besides increasing the involvement of suppliers in terms of product development activities, companies also tried to increase the aggregation level of outsourced components in the product architecture (Gadde and Jellbo, 2002). Not only did they increase the design responsibility of some suppliers, but they also broadened the scope to include more complex assemblies or functional modules with clear interfaces (Hsuan, 2001; Gadde and Jelbo, 2002; Mikkola, 2003). This practice, also known as 'modular sourcing', helped companies in the car and computer industry to mass-customise their products at an increasing speed, by redefining the way sets of car components were connected to each other (Baldwin and Clark, 1997; Fine and Whitney, 1996). Several manufacturers were thereby able to reduce the number of direct suppliers that they had to deal with, which lowered their transaction costs.

So far, we can conclude that in many industries companies have responded to the increasing demands on product development by outsourcing what they view as 'non-critical' manufacturing, assembly and logistics activities. Their motives for outsourcing have been partially related to freeing up internal resources for product development, but also increasing flexibility and reducing transaction costs. It is at the interface between outsourced activities and product development that the collaboration areas with suppliers have gradually been shifted from focusing on a production and logistics-oriented improvement towards optimisation of component design; this has resulted in lower manufacturing costs and faster manufacturing cycle times.

1.3.2 Strategic response II: Concurrent development and cross-functional collaboration

A second response to the aforementioned challenges was the adoption of concurrent development and engineering approaches with the associated increase in internal cross-functional collaboration. Besides achieving higher quality products at lower costs, the importance of bringing products to the market faster led several companies to adopt a new way of problem solving in product development. This approach became known as parallel development or concurrent engineering (Clark and Fujimoto, 1992). Successful companies were able to reduce the time-to-market by executing some of the product and process design/engineering activities in parallel instead of in sequence. For example, product designers provided design information to manufacturing engineers, which they could use to prepare the layout and choice of manufacturing technologies. This meant that the trade-off between product design aspects and manufacturing and logistics aspects took place earlier on in the design process than in the past (Smith and Reinertsen, 1991). This required some process adaptations and a more cross-functional communication between team members (Clark, 1989; Clark and Fujimoto, 1992). This is where we see the link between the outsourcing trend and the increasing use of concurrent product development approaches. Since suppliers often already possessed information on manufacturing technologies, they had to be involved earlier in the project. This earlier involvement came in conjunction with increasing responsibilities for more complex assemblies.

We can conclude that the restructuring of the product development process itself led to more parallel execution of product and process design and engineering. For this parallel development to succeed, suppliers also needed to be involved in earlier project phases in order to fine-tune the product and process design of components.

1.3.3 Strategic response III: inter-company collaboration

Companies increasingly engaged in collaborative arrangements with other companies in the area of technology and product development; this was in contrast to the more traditional 'arm's length' relationships and a simple reliance on their internal development capabilities. By comparing it to the outsourcing response, this response gives us insight into different, though complementary, motives behind manufacturers adopting supplier involvement as a strategy. As technological development becomes more multidisciplinary and dynamic, rather than relying solely on internal development, companies in technology-intensive industries (including electronics, chemicals, and instrumentation) are turning to other companies to obtain the technological know-how necessary to compete (Hagedoorn, 1993). Collaboration with other companies is becoming a means of tapping into external sources of knowledge and improving development speed (Håkansson, 1987; Quinn and Hilmer, 1994; Bonaccorsi, 1994). Furthermore, there are also obvious advantages in sharing the financial risks with other companies when developing new products, such as risks related to the shortening product life-cycles and the required investments in human resources, technologies and equipment. This is why companies have resorted to various hybrid forms of collaboration, such as mergers, acquisitions, joint ventures, strategic alliances, licence agreements and also collaborative arrangements with suppliers (Borys and Jemison, 1989). These hybrid arrangements can be categorised into horizontal and vertical collaboration forms. Horizontal collaboration forms refer to collaboration between two competitors or between companies in related or unrelated industries at the same stage of a supply chain. Dyer and Singh (1998) argued that there is a significant potential value of horizontal, inter-organisational relationships for accessing resources and creating competitive advantage. There has been a substantial growth in various sectors regarding the use of relatively formal forms of horizontal inter-company collaboration, such as strategic alliances in research and development (Hagedoorn, 2002). Horizontal strategic alliances in R&D have occurred particularly in those industries with a high technology content in their products, such as computers and telecommunication, semi-conductors, aerospace and defence. However, companies in the biotechnology and pharmaceutical sectors have been increasingly resorting to strategic alliances (Hagedoorn, 2002). Whittaker and Bower (1994) found that between 1977 and 1987, the 15 largest pharmaceutical companies in the US, UK Germany and Switzerland increased their external R&D alliances by nearly six-fold, on average.

Vertical collaboration forms refer to collaboration between two companies that are active at different stages in a specific supply chain, in other words between a buyer and supplier. From a manufacturer's point of view, vertical collaboration means the increasing involvement of suppliers in its product development process, in addition to the manufacturing and logistics areas. One of the motives for vertical collaboration in product development is the greater flexibility it can give to the buyer, especially when purchasing rapidly developing new technologies, fashion goods, or the myriad of components for complex systems (Quinn and Hilmer, 1994). It decreases a company's design cycle time, as suppliers have more specialised capabilities based on more personnel expertise and extensive technical knowledge in its specific area. In a similar way, suppliers are exposed to different customers, which enables ideas for improvements with one customer to be further developed and transferred to other customers. The financial risks are also reduced since the manufacturer does not have to invest in all of the component R&D programs, or in constantly updating its production capabilities for each component system. An example of how a company can take advantage of the potential benefits of collaborating with suppliers is the software publisher Microsoft's entry into the game console market in 2001.

Box 1.1 ***Microsoft's optimal leverage of supplier capabilities: the X-box***
Given the speed at which technologies develop and market opportunities come and go, in combination with their lack of experience in the hardware development and manufacturing activities, Microsoft decided to team up with suppliers instead of developing internal capabilities. They did this by involving the main hardware suppliers early on in the development process and by leveraging the specific manufacturing, sourcing and logistics capabilities provided by Flextronics. With the help of suppliers, Microsoft succeeded in introducing the X-box within 14 months, thus constituting a serious threat to competitors such as Sony and Nintendo (O'Brien, 2001).

1.4 Previous research on supplier involvement in product development

In the previous section we looked at the roots and motives behind the emergence of increased supplier involvement in product development. In this section we use previous research to gain a valuable insight into the benefits and the risks of supplier involvement, enabling us to derive the central research questions of our study.

The majority of studies on supplier involvement have investigated whether collaborating with suppliers in the early phases of a development project can improve the final product performance, final product costs, development costs and development lead-time (Clark, 1989;

Birou, 1994; Hartley et al., 1994, 1997; Ragatz, et al., 1997, 2002; Primo and Amundson, 2002). The underlying argument is that supplier involvement can result in a more efficient and/or effective use of internal and external resources, thereby helping to attain a project's development targets.

Besides these short-term benefits, a limited number of studies have pointed out that collaborations between manufacturers and suppliers can also result in other types of benefits that have a more long-term impact on the product development performance. These are more strategic benefits (related to creation of technological resources), and are not usually reaped after a single collaboration. For example, access to a supplier's knowledge and technologies can be a critical factor in the success of a project or for several generations of products (Håkansson, 1987; Bonaccorsi, 1997; Wynstra, 1998). This access cannot be developed overnight. Another benefit created over time is the alignment of the technology strategies of the manufacturer and supplier (Bonaccorsi, 1992; Monczka et al., 2000; Wynstra, 1998).

Although there is both anecdotal evidence and more systematically investigated results of supplier involvement, studies on supplier involvement do not always agree on the positive effects of supplier involvement on overall product development performance (Birou, 1994; Hartley, 1994; 1997). For example, Zirger and Hartley (1990) found that supplier involvement did not accelerate the project cycle time. Eisenhardt (1995), on the other hand, found that supplier involvement only accelerated product development in mature computer industry segments. Therefore, supplier involvement is not an approach that can be universally and unproblematically applied. Clark and Fujimoto (1991) pointed out that manufacturers that depend on suppliers' engineering capabilities may lose some negotiation power; a carmaker that loses engineering expertise in core component areas is endangering its technological capability in the long-term. These mixed results could imply that it is a strategy to be avoided. Stuart (1997) argues that, *'Although many managers now talk about their desire to turn their suppliers into development partners, the fact of the matter is that actually doing it, after decades of exploiting suppliers by pitting one against the other, is exceedingly difficult.'* It therefore takes time before the benefits of involving suppliers can be felt. Some researchers argue that companies have started to realise the importance of involving suppliers in the product development process, but have not yet discovered the means to successfully implement it (Handfield et al., 1999; Evans and Jukes, 2000).

If we examine the literature that attempts to investigate the reasons for these mixed results and/or the managerial implications of involving suppliers, at least five clusters of studies stand out. The clusters contain specific dominant notions that have contributed to our knowledge on supplier involvement. These clusters reveal specific aspects that are relevant to the types of supplier involvement and its management, and use different analytical perspectives and theoretical notions.

The first cluster has started to view the phenomenon of supplier involvement as a decision to outsource product development activities. These studies initially focus on two sub-decision variables that define the nature of outsourcing. Firstly, the form depends on the development responsibility that suppliers assume for the development of a specific part in the spectrum from functional requirements to the technical specification of the component. This is referred to as the 'design scope' (Sobrero and Roberts, 2001) or 'extent of supplier involvement' (Wynstra and Ten Pierick, 2000). Secondly, the nature of outsourcing is determined by the stage of the overall product development process at which the customer decides to start involving the supplier. Involving too many suppliers at an early stage makes the co-ordination of development tasks complex and costly. The supplier involvement can be timed so that different types of knowledge are introduced to match the overall technical progress of the project. A high degree of involvement does not always mean early involvement and vice versa. For example, some suppliers of black box parts with a high development responsibility may be actively involved during later stages, in order to truly benefit from the latest technology. Many studies therefore consider the moment of involvement to be an important decision variable.

The second cluster includes studies that consider involving suppliers in product development to be more effective when close and cooperative buyer-supplier relationships are adopted as opposed to adversarial approaches (Sako, 1993; Bruce and Leverick, 1995; Bidault et al., 1998). By studying mostly one-to-one buyer-supplier relationships, they provide us with insight into so-called success-factors for effective collaboration. Success-factors include relationship characteristics such as high levels of trust, management commitment, and certain managerial practices such as information sharing and risk-reward sharing.

The third cluster of literature has evolved from the idea that supplier relationships are characterised by the differences in risk and value that they can bring to the company. These differences result in the need for adopting different strategies to manage the risk and capture the value from the relationship. In other words, the focus is more on identifying risk factors and supplier roles and the implications for effective collaboration structuring mechanisms (Kamath and Liker, 1994, Bensaou and Venkatraman, 1995; Wynstra and Ten Pierick 2001; Lakemond, 2001 and Sobrero and Roberts 2002). One of the conclusions is that not all relationships in product development are equally intensive. These studies further combine the insights from the first two clusters. The management of supplier involvement is examined in terms of the different roles suppliers can fulfil in product development in relation to the different forms of structuring the relationship between buyer and supplier in product development. They pay particular attention to the appropriate co-ordination mechanisms to be used in situations that differ in terms of development risk, task interdependency, suppliers' development responsibility and the objective of the collaboration thereby creating more effective communication behaviours during the collaboration (Sobrero and Roberts, 2001).

The fourth cluster focuses on the role of a single actor, namely purchasing, in terms of relevant tasks and the conditions enabling its effective involvement in product development. These conditions relate to the organisational structure of the purchasing department and the effective integration of buyers in development teams. The skills and behaviour of buyers have also been investigated, as has the role of information technology as a facilitator for the exchange and communication of relevant information between the buyer and supplier for product development purposes (Anklesaria and Burt, 1987; Atuahene-Gima, 1995).

The fifth cluster of literature contains a limited number of studies examining the organisation and management of supplier involvement using process/activity-based models. These models are characterised by the identification of a larger set of relevant decisions and possible activities that can improve the design or reduce the development time needed for the overall development project. Of particular interest are the contributions by Wynstra (1998) and Monczka et al (2000), who aimed to provide a more integrated view of supplier involvement in product development. They acknowledge the need for managerial activities that link both the long-term, strategic management and the management of supplier involvement in specific development projects.

1.5 Shortcomings of previous research

In this section we identify a number of gaps that can be clustered into content and conceptual related shortcomings, on the one hand, and into methodological shortcomings, on the other. Wynstra (1998) argued that closer examination of the available research and literature reveals limitations regarding the *scope*, the *perspective,* the *cohesion* and the *empirical basis* of the research.

1.5.1 Conceptual and content-related shortcomings

Scope

The first major shortcoming that Wynstra (1998) identified was that most of the research until 1998 focussed on managing supplier involvement in *development projects*. The discussion was usually concerned with improving the efficiency of product development projects in terms of costs and time, and improving their effectiveness in terms of product quality and functionality. He argued that a systematic overview of the purchasing activities was lacking and that the scope was therefore limited. The literature review concompanies that many studies indeed adopt a project focus when studying supplier involvement (Dowlatshahi, 1998; Bonaccorsi, 1994; Sobrero and Roberts, 2001). Nellore (2000) characterises the focus of previous studies as taking an 'operational perspective on how to involve suppliers' and argues that few studies have taken a strategic perspective. His suggestion is to develop 'visions' for suppliers that can help OEMs (Original Equipment Manufacturers) to define clear expectations and thus to better utilise the core capabilities of the buyer and supplier companies. While there are studies that adopt alternative valuable levels of analysis (for example, pairwise dyadic relationships and inter-organisational networks of relationships; Håkansson, 1982), these perspectives should be regarded as complementary. Their inter-relationships must therefore also be investigated (Takeishi, 2001;406). The contributions of Wynstra (1998) and Monczka (2000) have extended the project or relationship view and developed a more comprehensive and detailed view of the relevant activities to organise and manage supplier involvement, taking into account the focal company's internal organisation and its processes. The exploratory nature of their research does mean that several issues remain unanswered.

The first of the remaining shortcoming relates to the lack of extensive validation of the suggested activities and processes for managing supplier involvement. We therefore need to verify whether the activities and suggested processes in these models are complete. Some activities are rather generic, while others are very concrete. The second shortcoming is that few studies are available that have investigated both the short-term results of suppliers in development projects and the long-term benefits and risks of supplier involvement. The studies focusing on the short-term results tend to ignore the potential beneficial and harmful effects that may only become visible on the longer-term. An exception is the study by Sobrero and Roberts (2001), where they actually measure both the direct results of the collaboration in a development project and the learning effects of supplier involvement. Although Wynstra (1998) identified and argued in favour of investigating both short-term and long-term supplier benefits, he does not explicitly measure them in his study. If both the short and long-term benefits of supplier involvement are taken into account, this may prevent misinterpretation and the drawing of false conclusions regarding the appropriateness of adopting a supplier involvement strategy with its practical implications.

So far previous studies have not provided conclusive insights into the set of contextual characteristics that determine the need for different management approaches or into structural characteristics of the relationships between the buyer and supplier. The studies that adopt a contingency perspective argue that, depending on certain contextual circumstances, not every company needs to adopt the same approach to involve suppliers, . These studies have introduced and studied a rather scattered set of different organisational and market variables related to methods of organising and managing supplier involvement. The factors range from specific *component characteristics* (complexity, novelty, uncertainty; Nazli Wasti and Liker, 1999), *relationship characteristics* (e.g. mutual interdependency), *project characteristics* (degree of innovation; Henderson and Clark, 1990; Wheelwright and Clark, 1992; Lakemond, 2001), *company characteristics* (company size; Spina et al., 2000, Wynstra, 1998) to *industry characteristics* (technological uncertainty; Eisenhardt and Tabrizi, 1995). We still need to identify potential contextual factors and to study what their relationship is to the form of the various processes deployed to manage supplier involvement effectively. This would provide insight into the explanatory strength of the contextual factors in explaining why supplier involvement performance differs across companies and development projects.

The final shortcoming in terms of research scope relates to the limited understanding of the conditions that impact on a company's ability to manage supplier involvement in product development. There is currently no clear conceptualisation of the factors that facilitate the management of supplier involvement. Several of the studies have focused on identifying the success factors in intensive collaborations between the buyer and supplier (Ellram et al., 1993; Bruce et al., 1995) or the conditions that foster learning. In particular, the collaboration has been argued to be more successful if it exhibits the following characteristics: a long-term character, mutual interdependency, shared goals and objectives ensuring a common direction, open communication, sharing of relevant technical, market and cost information requiring the development of trust, top management commitment and nurturing of the relationship (Ellram et al., 1993, 1996; Mohr and Spekman, 1994). Other factors argued to support the involvement of suppliers and purchasing in product development are related to the internal organisational structure of the purchasing and R&D departments, the quality of human resources and the availability and exchange of information relevant for the collaboration and decisions related to supplier involvement (Anklesaria and Burt, 1988; Wynstra, 1998; Wynstra et al., 2000). The combined role of internal and external factors supporting the management of supplier involvement has been neglected until now.

Perspective

Empirical phenomena need to be investigated from different points of view. A limitation of current research is that there are still unexplored perspectives in current research on supplier involvement (Takeishi, 2001). Perspectives can be understood as a lens through which to study an empirical phenomenon. It is more than a theoretical perspective. For example, studies can examine a phenomenon at different levels of analysis and focusing on particular elements of an empirical phenomenon and/or relationships between those elements. Such elements and the relationships are often captured in a conceptual/theoretical framework. Wynstra (1998) noted that many publications focus on purchasing and supplier involvement in product development as an inter-organisational phenomenon. He formulates this in the following way, *'both the supplier and manufacturer are seen as monolithic entities'* (Wynstra, 1998;5). This narrow perspective of existing research leads to the following biases. Firstly, when considering the role of the suppliers, few studies take into account the effects of reactions from suppliers to the strategies and instruments employed by the manufacturer. Secondly, research analysing the role of individual departments within the manufacturer with regards to the management of supplier involvement, focus primarily on the purchasing department. Wynstra (1998) argues that current research hardly acknowledges that, in reality, people from various departments manage supplier involvement in product development, and that they may have different, perhaps even opposing, ideas, interests and strategies. Takeishi (2001) argues the importance of studying the internal organisation in supplier involvement studies. His view is that studies regarding supplier involvement in the automotive industry have neglected the internal organisation of the focal company, relatively speaking. He says, *'In research on supplier involvement in the auto industry, only a few empirical studies have paid attention to automakers' internal organization for supplier involvement, and their attention has remained limited.'* (Takeishi quoting Clark and Fujimoto, 1991; Liker et al., 1995;406*)*. Most research in the domain of purchasing management does focus on the role of purchasing as an actor, and on the organisational and human resource aspects of its involvement in product development. Very few studies adopt a more integrated and process-oriented view towards supplier involvement. One of the few exceptions is Dowlatshahi's Early Supplier Involvement framework, in which he identifies specific tasks for actors such as R&D, manufacturing, purchasing and the supplier (Dowlatshahi, 1998). In that respect, the term '*purchasing involvement',* coined by Wynstra (1998), is somewhat confusing, given his explicit acknowledgement that the purchasing department is not the only actor capable of carrying out the various activities. We have clearly established that there is a need to further study supplier involvement as a process phenomenon whose management requires input from and the participation of multiple internal actors.

Cohesion

One of the shortcomings that Wynstra identifies is that previous research tends to fragmentarily identify a number of issues or processes for managing supplier involvement. This results in a lack of cohesion in the knowledge about their inter-relationships and about the implementation of supplier involvement. Indeed, the majority of previous studies simply provide managers with a lot of issues to consider (Ragatz, 1997; Bruce, 1995), presenting them as success factors. This allows managers to develop an agenda of critical issues but without fully understanding what the implementation and management will entail. In fact, few studies provide an in-depth picture of how specific managerial processes, such as supplier selection, relate to other processes, such as deciding when and to what extent to involve suppliers. One of the exceptions has been the contribution by Dowlatshahi (1998), who proposes a framework of critical tasks for several actors when trying to implement Early Supplier Involvement.

In general, companies do not fully understand the relationships between the decisions regarding supplier involvement and their intended market and technology strategy. In other words, supplier involvement is not a separate or isolated set of activities, but is embedded in, and is expected to support, overall company strategies. Studies focusing on the antecedents or the success-factors of collaboration with suppliers as a specific mode of developing new products are valuable, but are limited to the collaboration as a unit of analysis. This unit of analysis needs to be complemented with a broader perspective on the internal organisation and processes that actually realise the intended supplier contribution in the product development process. To some extent Wynstra's conceptualising and structuring of various elements of purchasing involvement has provided a framework that lists a set of generic activities related to organising and managing supplier involvement into different management areas. The activities in the framework are still rather general. Further empirical study is therefore needed in terms of the inter-relationships between the activities themselves and how they are embedded in the company's organisational structure, processes and strategy.

1.5.2 Methodological shortcomings

Empirical basis

In addition to the conceptual and content-related shortcomings, Wynstra (1998) argued that the empirical basis of available research was rather limited. Most studies were carried out in large-scale assembly industries such as the car industry (Clark, 1989; Helper, 1991; Liker 1997, Nazli Wasti et al., 1997; Dyer et al., 1998; McIvor, 1998; Evans and Jukes, 2000; Von Corswant and Tunälv, 2002) or the electronics industry (Mendez and Pearson, 1994; Nishiguchi, 1994). Consequently, little was known about supplier involvement in product development in other industries, such as those with unit/small series and process production. Brown and Eisenhardt (1995) expressed the need for research in non-automotive domains, to ensure that automotive-related results were not applied to other industries without understanding the differences. Since the mid 1990s a greater variety of industries have been studied, including: medical, telecom, textile, food, home appliances and truck industries (Wynstra et al. 2000; Tidd, 2000; Lakemond, 2001; Sobrero and Roberts, 2001). However, the dominant views still come from the major studies carried out in the automotive and electronics sectors.

One remaining question is to what extent industries, or the successful companies in these industries, have peculiar characteristics that would prevent us from generalising the findings. We therefore still need additional studies that focus on different industries. The researcher would need to scrutinise the appropriateness of the methodology adopted and the role of industry and company-specific factors in explaining performance, practices or organisational differences. An additional shortcoming that had not yet been identified by researchers in this field is the low level of replication of research models between different industries and researchers. Most research draws on meta theories or takes a specific element and puts it into a new conceptual model without first disproving the original model. Replication would enable earlier propositions and theoretical models to be validated or disproved. A related shortcoming is the lack of longitudinal case studies in research on supplier involvement. It is generally accepted that by adopting multiple methodologies allow the data to be triangulated. The methodology chosen is partially determined by the nature of research questions asked and the level of knowledge already available regarding a phenomenon. Given the nature of the shortcomings in earlier supplier involvement research, we can argue that supplier involvement research needs a combination of deductive and inductive approaches to increase the knowledge about practices and effects of supplier involvement. Since supplier involvement is a dynamic process that unfolds over time, we need a methodology that allows us to observe these dynamics. Longitudinal and participatory case studies allow this type of observation of dynamics over time and result in an in-depth understanding of the context in which supplier involvement takes place. Despite the increase in studies that use surveys or case studies, few have opted for longitudinal observatory or even participatory research methods.

1.6 Problem statement

In the previous section, four major shortcomings regarding studies on supplier involvement previously identified in the study by Wynstra (1998) have been taken as a point of departure for identifying the remaining gaps in the literature. In this section we define the gaps in terms of a relevant problem statement and the central research objective and research questions.
Up until now, studies on the results of supplier involvement in product development have pointed out that it certainly does not improve product development performance across the board. Previous research has provided some empirical evidence of both positive and negative effects of supplier involvement. The mixed results have been complemented with the possible additional benefits and risks, which are of a more long-term and strategic nature (Quinn and Hilmer, 1994; Bonaccorsi, 1994; Håkansson, 1993). Several studies have developed partial explanations by investigating the conditions that are present in successful manufacturer-supplier relationships (Ellram, 1993; Mohr and Spekman, 1994), the characteristics of the internal organisation (Takeishi, 2001), or the way that supplier involvement is managed. They have largely focused on the general relationship or specific collaboration between the buyer and supplier in development projects.

No one has yet explained what the critical internal management capabilities are to leverage the external resources and capabilities through supplier involvement over a longer period (Takeishi, 2001). Despite this growing recognition of the importance of supplier involvement, few studies have provided a comprehensive view of what processes are needed to organise and manage supplier involvement in specific projects while generating strategic benefits and balancing potential risks. We can therefore define our problem as:
'*there is a lack of sufficient empirical understanding of the critical processes and conditions for effective supplier involvement that allow companies to achieve their short-term product development targets and strengthen their ability to improve the performance of future projects*'.

We now need to define the research objective(s) and research questions related to the problem definition (Verschuren en Doorewaard, 1995). The overall research objective is:
To develop a framework that identifies the objectives, critical managerial activities and conditions for effectively leveraging supplier capabilities in product development in such a way that the short and long-term objectives of the company are realised.

From this central research objective we can formulate the following research questions:

1. What short and long-term objectives may underlie a company's intention to involve suppliers in product development?

Although various studies have looked at the results and effects of supplier involvement within the context of a given development project, we need a better understanding of the various performance objectives of supplier involvement in product development. Which of the targeted benefits dominate in the studies, and which are given the highest priority? What results can be achieved when involving suppliers in product development projects? In addition to their contribution to the performance of a development project, what long-term benefits are reported in literature and are realised? What trade-offs are there between various short and long-term objectives of supplier involvement?

2. What management processes are critical for achieving the short and long-term objectives of supplier involvement?

We argued that there is a need to better understand how companies can prepare, organise and execute the involvement of suppliers in their product development process. One aspect here concerns the activities and processes by which a company can create and exploit external resources. We will therefore investigate which internal and interorganisational processes and activities are effective in achieving the desired results from involving suppliers in product development. Despite the contributions provided by several researchers (Wynstra, 1998; Monczka, 2000; Evans and Jukes, 2002; Takeishi, 2001; Dowlatshahi, 1998), we still need to verify whether the relevant processes have been identified in these models. Which of the suggested supplier involvement management processes can be omitted? Are there any additional relevant processes? Which ones need further operationalisation of underlying activities? We also need to deepen our understanding of the logical and chronological inter-relationships of the various managerial activities and processes in the context of the development project's phases. Is there a sequential, interactive and iterative pattern present in the way companies execute these processes?

3. What factors actually support the execution of processes aimed at managing supplier involvement in product development?

In addition to the processes, we have observed that several studies have identified a number of factors that can be regarded as the conditions for successful cooperative buyer-supplier relationships. These are referred to as success factors. Some authors have studied factors that are specifically attributed to the relationship between the buyer and supplier, while others have focused on structural and human factors that are more internally oriented. Until now, it has not been clear how they jointly enable the company to effectively prepare and manage the involvement of suppliers in product development is not clear yet. We need a better understanding of the conditions that can support the company in achieving improved supplier involvement management.

4. What contextual factors increase the need for executing the processes aimed at managing supplier involvement in product development?

Since many authors have demonstrated the variation in the companies' surrounding environments, many have argued that there are equifinal[2] organisational solutions that can be

[2] Different solutions with the same result

equally effective in dealing with environmental change and complexity (Van de Ven, 1985). If we apply a similar line of reasoning to organising and managing supplier involvement in product development, we could argue that companies need different organisational arrangements and processes to achieve a high performance. In other words, performance differences related to supplier involvement may be the result of a specific approach that did not fit the type of environmental conditions in which the company in question operates. We therefore focus our attention on further investigating the circumstances under which companies need different levels or forms of supplier involvement management processes.

5. How can an analytical framework be used as a reference model for diagnosing and improving the processes and conditions underlying the effective management of supplier involvement?

In general, conceptual models focus on the identification of a theoretical set of variables and derive managerial implications at some later stage. There is a need for a balanced contribution related to studies of managerial action, to provide both theoretical and practical, relevant and useful contributions. In particular, we argue that the model must help both academics and practitioners to understand the phenomenon of supplier involvement. The practical usefulness of conceptual models can be derived from their value in supporting managerial decision-making in the area of supplier involvement. In this study we are therefore interested in investigating how the development of a particular conceptual framework can help us to detect and prioritise the areas for improvement regarding the management of supplier involvement. In this way we intend to add to the few studies that have included conceptual models to provide practical scrutiny, and to give companies instruments that help them in the complex reality of managing supplier involvement.

1.6 Research design and methodologies

The present thesis is the result of an interactive process of combining and adapting theory and empirical data using different methods. In the following subsections, the points of departure and the research phases and methods adopted are discussed.

1.7.1 Points of departure

An important element in designing the research is the choice of the research approach. Van Aken (1994) distinguishes between two approaches: the 'empirical approach and the 'design approach'. The empirical approach aims to answer the central question, 'How do organisations work in practice'. Such an approach is based on following the steps of the empirical cycle. On the other hand the design approach is aimed at answering the normative design question, 'How should organisations work'. Van Aken proposes the reflective cycle as an appropriate approach to develop scientific knowledge in conjunction with designing relevant solutions for a practical problem.

Given our problem statement, we can characterise our research as largely design-oriented and qualitative in nature. We aim to explore both the management of supplier involvement and to explain the results. This characterisation is also driven by the novelty and the way that interest in and knowledge on the topic of supplier involvement initially emerged. Supplier involvement was first considered to be a practical phenomenon, which could contribute to the improvement of organisational performance. The mixed results of some empirical studies and the increase in anecdotal evidence indicate that our knowledge of this empirical phenomenon is still limited. Moreover, companies are struggling with different complex managerial and organisational decisions in order to benefit from supplier involvement. We therefore face a challenge to rise above the reporting of anecdotal evidence. We need to design and carry out more substantial empirical studies to both theorise and design well-founded guidelines that are useful for the design and management of organisational processes. Satisfying both objectives is a huge challenge. The understanding of extant theory is an important point of departure if we are to satisfy the objective of theory development. The mature organisational, strategy theory fields and innovation fields have provided researchers with some high level theoretical building blocks in this area.

The design of the various process steps needed for theory development and/or theory application should occur in a conscious way. According to Van der Zwaan and Engelen (1994), the researcher needs to go through three general phases. These phases are: *exploration, explanation* and *validation*. The available knowledge about the topic knowledge has not led us to choose for a typical deductive hypothesis testing research design. Instead, we chose to combine several primarily qualitative research strategies. Hypothesis testing design is not considered appropriate to bridge the so-called relevance gap (Mathyssens and Vandenbempt (2003;596). They argue that qualitative interpretative research is needed and allows for explanations that are highly contextualised and lead to actionable recommendations and prescriptions to managers. Combining research strategies points to the iterative nature of the research process in which evidence following from the different methods have been used in the exploratory, explanatory and validating phases of this research. The way how to combine and time the use of different strategies and methods depends on the nature of the research questions. Yin (1994) and Van der Zwaan (1994) argue that a natural, though not exclusive fit, with one or more research strategies can be distinguished for different types of research questions. Furthermore, Brewer and Hunter (1989) argue that the explicit combination of research methods within one research project might enhance theoretical validity, if they fit with the research questions and the research strategies are complementary in terms of their weaknesses and strengths. Such an approach is often referred to as a triangulation of research methods, but can equally apply to using multiple data sources to substantiate the findings. Triangulation enhances the validity of the theoretical knowledge generated (Yin, 1994).

Dubois and Gadde (2002; 555) argue in their discussion of case study research that not only combining research methodologies is important but also '*By going 'back and forth' from one type of research activity to another and between empirical observations and theory, the researcher is able to expand his understanding of both theory and empirical phenomena*'. In this research design we consider this as a spiralling process between the empirical data and insights on the one hand and the framework and underlying theoretically derived concepts and perspectives on the other hand.

We will now discuss the research design in more detail. We particularly focus on the chosen research strategies and methods in the light of the nature of the research questions and address coherence and validity aspects. A detailed explanation of the way in which each of the research methodologies has been used will be described in each of the empirical Chapters (4,7,8). A further reflection on the extent to which reliability and validity of methods and findings have been safeguarded can be found in the final chapter.

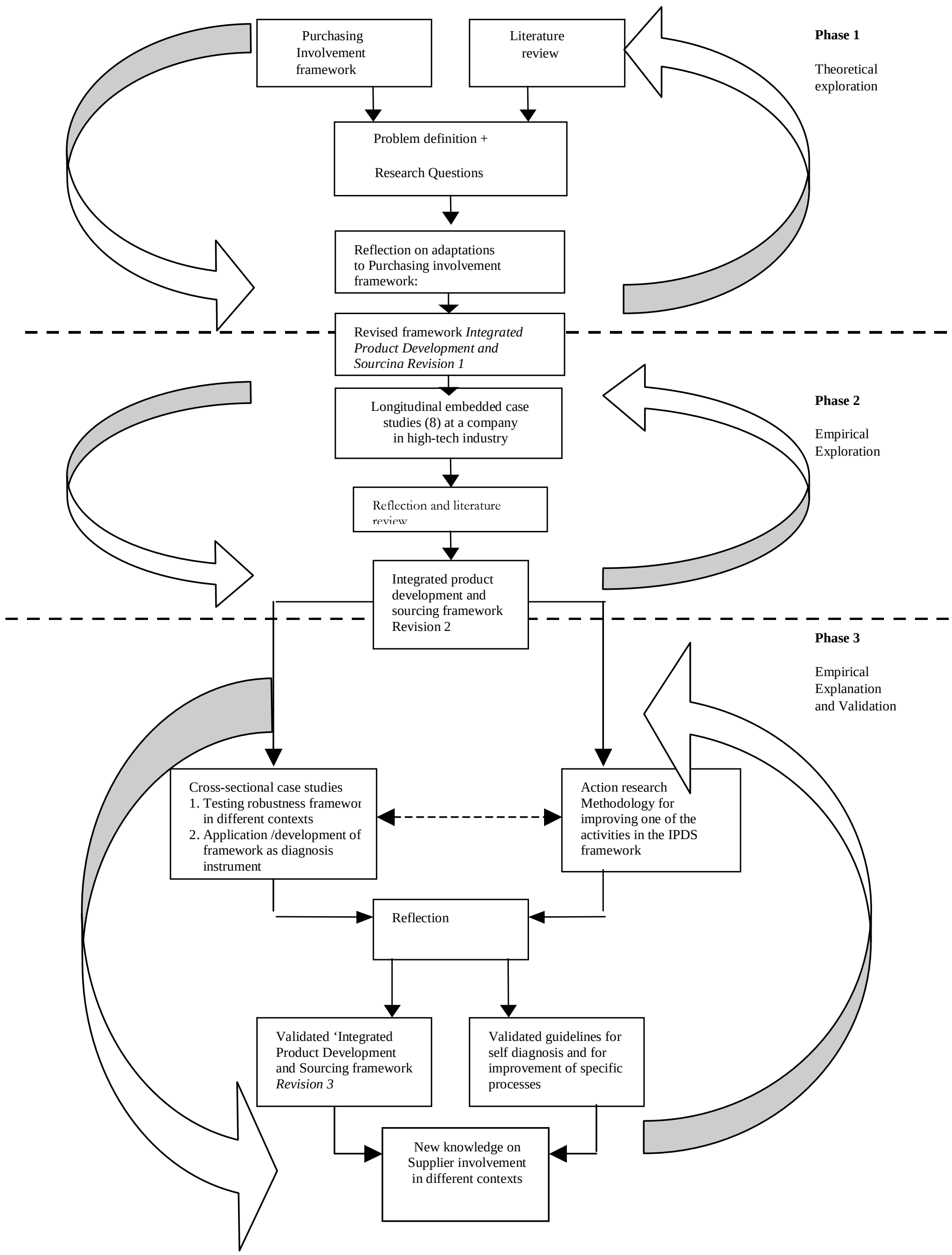
1.7.2 Research phases, iterations and methodologies

Figure 1.1 shows a schematic Figure of the research design in terms of its cycles and chosen research strategies and methods. The large circular arrows signal that the process is not a linear sequence of research activities. We emphasise that reflection and the need for adaptations were gradually emerging based on various mini cycles of collecting data, reading literature and reflection. We did however plan at the intersection between two different phases to reflect on patterns in data collected, using the analytical framework and additional relevant literature. This way, we could define and incorporate the adaptations to the framework in our research instruments before going then to the next research phase.

In the first *theoretical exploration phase*, we reviewed the literature to explore the findings of previous studies and theories regarding supplier involvement. This theoretical exploration showed us a number of gaps not filled by current theory. We followed Eisenhardt's (1989; 536) advice to define the research problem and formulate specific underlying research questions. The current knowledge on the management of supplier involvement pointed to a lack of an in-depth and integrated view on the conditions and processes allowing for effective management of supplier involvement in the product development process. In addition, we tentatively used an existing framework that identifies the key constructs in line with the formulated research problem and questions. Dubois and Gadde (2002) emphasise the importance of using a tight and evolving framework. The tightness reflects the degree to which the researcher has articulated its preconceptions, helping to create a reference and to function as a guideline for entering the empirical world. The reason for a framework evolving during the study is that empirical observations inspire changes of the view of theory/relationships and constructs and vice versa.

We decided to use an existing analytical framework allowing us to empirically investigate the research questions referring to conditions, managerial activities and results of supplier involvement. In management studies an analytical framework is supposed to support the researcher in identifying the problems to be handled, to structure the situation assessment in order to identify the intervening variables, and to identify alternative courses of action (Takeishi, 2001).

Figure 1.1 Research process design



The Purchasing Involvement model (Wynstra, 1998) represents an initial analytical framework with different entry points, which makes it possible to address multiple research questions at the same time. Compared to the available frameworks in literature, it represented the most complete and comprehensive framework in terms of the basic managerial activities and conditions. It therefore allowed us to study a complex and dynamic phenomenon. In this way, we started out with a tight framework. At the same time we allowed the framework to evolve by going back to the literature and using it in different empirical contexts.

After the literature review, we still detected a need to ascertain whether these listed activities and conditions were complete and provide sufficient detail. The framework needed five a priori conceptual adaptations to study the management of supplier involvement at multiple levels of analysis and in terms of the basic constructs. We first introduced the objectives of supplier involvement in both the short-term and long-term as relevant performance dimensions in order to study the relationships between the managerial activities and conditions that are critical in achieving them. We then added additional driving factors and enabling factors. This resulted in a revised Purchasing Involvement model now referred to as the analytical framework for 'Integrated Product Development and Sourcing' (IPDS). The final adaptation consisted of representing the framework as an Open System model.

Next, the empirical research phases were started. They had to be based on a flexible and in-depth research strategy, given the combined exploratory and explanatory nature of the questions. The second phase of the research design concerned the *empirical exploration* using the analytical framework to analyse supplier involvement in product development. During the exploration phase we opted for a longitudinal embedded case study to address the need to explore the variables in more depth and to explore dynamic patterns of events. According to Eisenhardt (1989), the case study is a research strategy, which focuses on understanding the dynamics present within single settings. Since collaboration and associated managerial activities are dynamic by nature, we decided that we would gain the best understanding of the phenomenon by selecting a case study company in which we could make longitudinal observations of the events and activities. According to Van de Ven (1992;175), [in studies that aim to understand how to manage the formulation or implementation of an organisational strategy], it is necessary for researchers to place themselves into the manager's temporal and contextual frames of reference. We used therefore a mixture of retrospective and real-life case studies of supplier involvement that were embedded in a number of different development projects. The results of the longitudinal case study suggested the need for several adaptations to the listed activities and conditions. Before making any adaptations, we returned to the available literature. In particular, we found that by further detailing, adding and regrouping activities, the empirical reality could be better matched and the explanatory power of the problems and outcomes observed could be improved. After reflection, the IPDS framework was adapted, resulting in a second revision of our model.

In the third *empirical explanation and validation phase*, we aimed to test the robustness and validity of the revised framework by applying it in different company contexts. We chose a combination of different qualitative research methods. We first conducted a number of cross-sectional case studies at companies operating in different industries, in order to understand how realistic our framework and adaptations have been. Moreover, we further examined whether and how the analytical framework can be used to diagnose supplier involvement in product development. Although we wanted to test the generalisability of the hypothesised relationships between the conditions, processes and supplier involvement results via a survey, the results were not available in time to include in this thesis.

Besides these two objectives, our additional objective was to provide guidelines for carrying out a management process that came out as one of the critical processes in the case studies. We therefore continued the longitudinal case study in the form of an action research project. During this phase, one of the management processes was further supported with newly developed guidelines and tools. Between the cycles, the iterations between data and our framework determined also the need to verify additional literature which could challenge or confirm our insights. In Table 1.2 we connect the type of research questions with the various types of research and appropriate methodologies outlined earlier.

Table 1.2 Empirical research methods and application areas

Research Strategy	**Form of Research Question (Yin, 1994)**	**Type of research** (Adapted from Van der Zwaan, 1990;44)							
		Exploration		Description		Explanation		Validation	
Case study	how, why, (what)	***		*		*	RQ 2,3,4,5 in Phase 3		
Longitudinal Case study	how, why, (what)	*	RQ 1+2+3 in Phase 2	***	RQ 1+2+3 in Phase 2	**			
Action Research	Not identified			*		*		*	RQ 5 in Phase 3

Legend
* this research strategy is occasionally used for this type of research
** this research strategy is regularly used for this type of research
*** this research strategy is frequently used for this type of research

Two important questions in adopting qualitative research need to be addressed. The first question concerns whether the study is reproducible by others in the future. Can other researchers follow the same steps and achieve similar results. Awareness of external reliability is crucial in (partially) subjectivist approaches according to Miles and Huberman (1994). The danger of the researcher influencing the study is real and can inhibit results to be error-free. I have become and been largely aware of the need to continuously ask myself how my interaction with interviewees and other actors, data collection, analysis and interpretation affect the object (actors) under study. It is inherent in combining different qualitative studies that exact reproducibility is impossible, however it is a methodological issue that should not be taken lightly. Therefore, a detailed account of research steps and points of departure, methods and lenses adopted should enhance the external reliability of the study.

The second question regards how can the researcher extend his conclusions beyond the investigated sample and in fact achieve sufficient external validity? The generalisation issue in science has been predominantly addressed in two ways: statistical and analytical generalisation. Whereas statistical generalisation aims at generalising results from a randomly drawn sample to a population, analytical generalisation does this to an (emergent) theory (Yin, 1994). Qualitative research cannot rely on statistical inference because it can typically not estimate the variability of the total population. Simply increasing the number of cases does not help in achieving statistical generalisation. According to Miles and Huberman (1994), the reason is that '*...we are generalising from one case to the next on the basis of a match to the underlying (pattern model), not to a larger universe*'. Determining external validity of qualitative research is not a binary decision. Kennedy (1979) argues a more appropriate term would be to emphasise the strength and range of external validity or generalisability. In qualitative research, 'the receivers of the information must determine whether it [the finding] applies to their own situation'. Judgements about the range of generalisation are the responsibility of the receiver of information, rather than the original generator of information. The evaluator must be careful to provide sufficient information to make such generalisations possible' (Kennedy 1979; 671-672). The researcher can strengthen the external validity of the findings by deliberate selection and comparing of cases that differ or are similar on some pre-established criteria and by providing sufficient rules of sampling, data collection, analysis and interpretation and theorising. In this work we have conducted three different but connected qualitative field studies. At the beginning and end of each chapter the specific steps that are taken are described as to what questions are still open after each field study. We do however provide also specific information about the contexts in which we have studied the empirical phenomenon of supplier involvement (e.g. industries, projects and type of parts). We argue that our findings of this study can be generalised to companies, typically developing and producing physical products (and embedded services) that involve other companies in product development. The other companies are referred to as 'suppliers' that provide input and ultimately co-ordinate the manufacturing or actually manufacture parts they supply to the buying company.

1.7 Structure of the study

The remainder of this thesis is structured as follows. *Chapter 2* provides a review of previous literature on supplier involvement, looking in-depth at which areas and what conceptual approaches have been used to study the phenomenon and its reported performance results. *Chapter 3* forms the synthesis of Chapter 1 and 2, and can be considered as the preparational chapter before starting the longitudinal case study and cross-sectional case studies during the empirical research phases. Based on an existing framework to analyse purchasing involvement in product development, adaptations are proposed that allow the management of supplier involvement to be investigated from an integrated contingency perspective. *Chapter 4* describes the longitudinal case study starting with the adopted research design and methodology and presenting eight embedded cases of manufacturer-supplier collaborations at Océ. The case results are analysed in *Chapter 5,* using the Integrated Product Development and Sourcing framework; preliminary conclusions regarding the critical processes and conditions are drawn. In *Chapter 6* we determine the need for adaptations in the initial framework. Several adaptations are proposed, including a further operationalisation of constructs and a reconceptualisation of the activities in the IPDS framework. The revised IPDS framework is further tested in *Chapter 7*, in a series of cross-sectional case studies in four different companies. *Chapter 8* presents the last part of the empirical research phase and presents the results of the action research project at one of the case study companies. The action research resulted in the development of a methodology and guidelines for carrying out a key process aimed at managing supplier involvement in product development. *Chapter 9* reflects on the extent to which the research questions have been answered. It presents the final conclusions, limitations, recommendations for further research and the contributions to practitioners.

1.8 Conclusions

In this chapter we have provided an initial background against which the growing adoption of supplier involvement and attention for the phenomenon as a subject of research can be understood. We linked the increasing interest in studying supplier involvement in product development with three strategic responses of companies to the challenges arising from the changing competitive, societal and technological environments in which they are operating. Supplier involvement emerged from the trend where companies started to outsource manufacturing, assembly and subsequently design activities to benefit from the resulting specialisation efficiencies. The increased adoption of concurrent development approaches in combination with cross-functional collaboration has also made supplier involvement more important. We can understand the growing interest in supplier involvement in terms of the benefits of collaboration as a way of creating access to external knowledge or skills which are prohibitively expensive or too risky to develop internally given the increasingly uncertain and fast changing upstream and downstream markets. We examined previous research to determine what is currently known about the phenomenon and the explanations suggested regarding the actual effects of supplier involvement. Based on this analysis, we argued that supplier involvement has been insufficiently studied in terms of the different short-term and long-term results, and in terms of the underlying supplier involvement processes and conditions critical for achieving them.

This study therefore aims to extend the body of knowledge on the interplay between sourcing and product development. It specifically aims to distil the effective ways of using external resources and the capabilities of suppliers to strengthen product development performance on the short and long-term.

Chapter 2
Exploring supplier involvement in product development: a literature review

In this chapter we explore the literature on the management of supplier involvement in product development. We do this with two main objectives in mind. The first is to examine the sources and the evolution of interest in supplier involvement as an empirical phenomenon and research topic. The main contributions to the understanding of supplier involvement will be grouped into distinct clusters that discuss either a specific topic associated with supplier involvement or use a specific conceptual approach to understand the management of suppliers. The second objective is to analyse the available and missing knowledge, which will provide the input to develop an initial framework for analysing supplier involvement practices and their actual results in the next chapter.

2.1 Supplier involvement in product development: a definition

The phenomenon central to this study is what we refer to as 'supplier involvement in product development'. Many different terms have been used in various studies and publications and we therefore need to clarify what we actually mean by supplier involvement in product development. In the remainder of this thesis we adopt the following working definition:

'Supplier involvement' refers to the contributions (capabilities, resources, information, knowledge, ideas) that suppliers provide, the tasks they carry out and the responsibilities they assume regarding the development of a part, process or service for the benefit of a current and/or future buyer's product development projects, aside from (co-ordinating of) the manufacturing and/or delivery of the part, process or service.

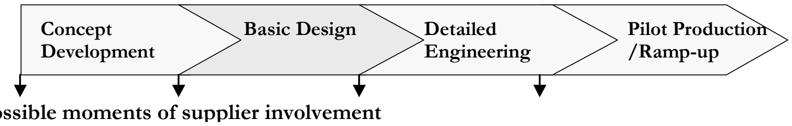
In this definition, we explicitly demarcate the domain of collaboration and the type of actors to be considered, and distinguish the three dimensions of involvement.

We have demarcated the domain of cooperation between two companies to be limited to product development. Product development usually consists of the following four to five stages (Clark and Fujimoto, 1991): *Concept development* → *Basic design* → *Detailed engineering* → *Pilot-production/ramp-up*. We are specifically studying the involvement during these stages and therefore do not focus on collaborations during the regular production or in areas of basic and applied research, which usually precede these product development stages. In the latter two cooperation domains, companies often do not involve the suppliers who ultimately deliver the final part. A part encompasses the physical object or process subject of development, and can refer to a component, assembly, module or a system that is part of the final product. We do acknowledge that supplier involvement can also occur in the development of new services which may be offered in conjunction with a physical product. However, we choose to focus on the development of new products and to include the service dimension of supplier involvement only if it is part of the final product.

It is also important to note that supplier involvement concerns the collaboration between two specific types of actors, namely, the buyer and supplier. We therefore consider any company to be a buyer as long as it can be found at a stage in a specific supply chain where it depends on external companies for the delivery of goods or equipment. Consequently, these companies do not include competitors. This situation is often referred to as 'vertical cooperation' as opposed to horizontal cooperation between two or more competitors (Håkansson, 1987). We consider a 'supplier' to be a company that has the intention to produce, assemble or co-ordinate these activities with other supplying companies. We do not consider actors such as scientific or knowledge-based institutions.

Supplier involvement is characterised by several dimensions. In the literature, supplier involvement is viewed as 'the integration of capabilities' (Dowlatshahi, 1998), or as 'the contributions suppliers provide' (Lakemond, 2001) or 'as the information suppliers provide and their participation in decision making' (Handfield, 1999). In the aforementioned definition we made a distinction between the supplier's *contributions*, *tasks* and *responsibilities,* as they more accurately indicate the different dimensions that the involvement consists of. Suppliers can *contribute* to product development in a variety of ways. They use their capabilities to improve the product development performance of their customers. For example, their prototyping expertise, which the customer may not possess, can be critical in achieving short test cycles and can therefore speed up the overall project cycle time. In addition to capabilities, a supplier allocates resources to a specific buyer; these could be financial, human or capital resources. These resources can be a critical condition for making their involvement successful. Contributions by suppliers can also consist of specific information, ideas and knowledge that they provide to the project team, such as providing feedback on which manufacturing tolerances are possible or suggesting alternative materials. This information can help to better align the desired functional performance and the 'makeability' of the component. The aforementioned contributions can be linked to the variety of *tasks* a supplier can perform during product development. These tasks are a selection of the total number of activities that need to be performed in a product development project. They can refer to activities during concept development, during detailed engineering or production ramp-up. The possible moments of supplier involvement are depicted in Figure 2.1.

Figure 2.1 Supplier involvement moments in different product development stages



Possible moments of supplier involvement

For example, a buyer can develop the functional specifications for a particular part while the supplier carries out the subsequent tasks of designing the component based on those functional specifications. The division of tasks between the buyer and supplier implies a varying degree of participation in the decision-making processes surrounding each task and the *responsibilities* assumed by each party. For example, when choosing a specific production technology both parties can agree that the supplier is responsible for the appropriate evaluation of alternative technologies and for detailing the design based on a particular production technology. The supplier's responsibilities are those tasks and deliverables for which it is held accounTable.

An important note needs to be made here regarding the targeted time horizon for which supplier involvement is used. As mentioned earlier, supplier involvement often takes place during different stages of a specific development project. However, we explicitly describe how a supplier might be contacted in advance of, or in parallel with, a development project[3] with the aim of exchanging and testing ideas and concepts for a part to be used in a future project or series of projects (Monczka et al., 2000). The associated benefit is argued to speed up the development time of product development projects.

Finally, supplier involvement takes place within the context of a new or existing relationship between the buyer and supplier. There appears to be general agreement in the literature on the cooperative nature of the relationship between the buyer and supplier adopting supplier involvement (Ellram, 1995; Krause and Handfield). We also assume a certain degree of cooperation is present for the contributions of suppliers to be brought into the project. However, we do not solely characterise supplier involvement as a strategic partnership or alliance, as some authors do (Bonaccorsi, 1994; Ellram, 1993). Supplier involvement can take place under varying conditions requiring different communication interfaces and different intensities and frequencies of communication (Sobrero and Roberts, 2001; Wynstra and Ten Pierick, 2000).

Now that we have provided a preliminary working definition of the phenomenon, we need to examine the current body of knowledge regarding the results of supplier involvement, the way they are explained and what the underlying (conceptual) approaches are. We have first made a historical overview of the most influential contributions to the knowledge on supplier involvement; this should help us to further understand the elements of the phenomenon we are studying.

2.2 The rationale behind supplier involvement: an assessment of benefits, risks and results

The attention for the phenomenon of supplier involvement in product development in the academic literature emerges from various literature and discipline streams, each with different

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[3] We are aware of the partial overlap of the terms 'advanced development' and 'applied research'. Advanced development clearly aims to work on concrete products or functional parts (which can be a technology) to be integrated in future product development.

foci and perspectives. The phenomenon can be studied in terms of its potential benefits and risks, but most importantly in terms of its actual effects on product development. In the following sections we review the underlying explanations and further studies dealing with various dimensions of supplier involvement. We pay specific attention to the findings on managerial implications and conceptual approaches and the theoretical perspectives adopted.

2.2.1 Potential benefits of supplier involvement

The specific attention for the potential role of suppliers in product development can be traced back to 1979, when Rubenstein and Ettlie (1979) argued that suppliers are a potential source of innovation in terms of new or improved products, components, systems, materials and designs for automotive manufacturers. In the decades that followed, the phenomenon of supplier involvement became a topic on more research agendas. Several researchers pointed to a number of (potential) benefits associated with supplier involvement. The overview in Table 2.1 presents several significant studies that explicitly outlined different benefits associated with supplier involvement

Table 2.1 Benefits associated with supplier involvement

Author	Suggested benefits
Burt, (1989)	▪ Cost reduction ▪ Increased development speed ▪ Performance improvement
Clark (1989)	▪ Lead-time reduction ▪ Development man-hours reduction ▪ More unique parts, better product performance
Van Hooland and de Meyer (1990)	▪ Better manufacturability
Birou and Fawcett (1994)	▪ Better resource utilisation ▪ Development and sharing of technological expertise ▪ Network effectiveness
Mendez and Pearson (1994)	▪ Efficient manufacturability ▪ Minimisation design-to-market cycle time
Bonaccorsi and Liparini (1994)	▪ Reduction development costs ▪ Higher product quality with fewer defects ▪ Reduced time to market ▪ Supplier originated innovations
Zirger and Hartley (1997)	▪ Time savings reduction part production problems ▪ Easier communication ▪ Early problem identification
Gupta and Souder (1998)	▪ Reducing development cycle time
Swink (1999)	▪ Improvement of manufacturability
Handfield (1999) and Monczka (2000)	▪ Alignment of technology roadmaps/strategies
Ragatz (1997)	▪ Improved access to a critical technology
Nellore and Söderquist (2000)	▪ Full utilisation of external supplier investments
Dyer (2000)	▪ Improved differentiation/innovative capability
Von Hippel (1988)	▪ Source of innovation
Gadde and Snehota (2000)	▪ Contribution to product differentiation (impact on revenues)
Sobrero and Roberts (2002)	▪ Increasing the overall efficiency of the development process. ▪ Tapping into external resources, otherwise inaccessible, to augment the internal assets base.

Several groups of benefits associated with supplier involvement emerge from this overview. For example, the benefits can be grouped according their short-term and long-term character or according to their operational and strategic character. Sobrero and Roberts (2002;179) argue that a trade-off may be present in two types of benefits, *'...a purely financial evaluation based on short-term observations of such impact (of supplier involvement) might underestimate the effect deriving from changes in the competence set which needs longer time spans to become visible.'* We argue that, in general, those benefits that are associated with meeting project targets have a short-term and operational character. Other less tangible benefits have a long-term or a strategic character, that do not necessarily directly contribute to the current development project performance and they may only become visible to the manufacturer in a future development project. We therefore propose to distinguish between short-term operational benefits, on the one hand, and long-term strategic benefits, on the other hand. Both groups of benefits may be useful for a company in setting their objectives regarding supplier involvement for the short and long-term. Moreover, this distinction points to the possible trade-offs that should be managed when involving suppliers.

Short-term operational benefits of supplier involvement

The most frequently mentioned short-term operational benefits relate to the contribution of supplier involvement to the (1) *improvement of product quality*, (2) *reduction of product cost*, (3) *reduction of development time and* (4) *reduction of development costs*. Supplier involvement has been argued to lead to increased product quality, which can be observed in terms of the improved functional performance of the design, increased product durability and reliability, and better serviceability (Clark, 1989; Bonaccorsi and Lipparini, 1994; Kamath and Liker, 1994; Wasti and Liker, 1997; Ragatz et al. 1997, 2002; Primo and Amundson, 2002). This improvement can occur as a result of a suppliers' more in-depth knowledge about certain components and technologies. Suppliers may be able to suggest the use of alternative components that can increase the reliability of the part. Furthermore, suppliers might be specialised in a more specific domain and use their experience with other customers to solve the problems encountered during development.

A number of product cost-related benefits are also identified. Suppliers can help to reduce the unit cost of the part by actively participating in fine-tuning the product design specifications with the process specifications. Suppliers usually possess in-depth knowledge about the behaviour and possibilities of their production and assembly equipment. Their assessment and suggestions on appropriate production technologies and feasible tolerances may therefore reduce the manufacturing time and rejection costs, and can consequently lower the unit cost of the part (Dowlatshahi, 1998). Moreover, suppliers can reduce product costs by suggesting alternative materials or components (Wynstra, 1998). These materials and components may directly lower the product cost. Alternatively, the choice of a more expensive material may provide higher reliability and thereby indirectly reduce product cost through lower rejection and servicing costs. Material or production costs may also be reduced through supplier-driven simplifications of the design (Sobrero and Roberts, 2002) or a reduction of the number of components, or due to suggestions of alternative production techniques. These contributions can result in a reduction in the final product costs.

Supplier involvement can lead to shorter project development times. By bringing suppliers in early in the design process, they can help the project team to identify potential problems in time so they can be resolved in advance, thereby speeding up the development process (Clark, 1989; Meyer, 1993; Eisenhardt and Tabrizi, 1995; Hartley et al., 1997; Ragatz, 1997, 2002; Zirger and Hartley, 1997; Gupta and Souder, 1998). Supplier involvement can reduce the number of design changes, or at least limit their delaying effects, if the input regarding manufacturability or functional performance aspects are brought into the project early enough. Their input looses its value as more degrees of freedom have been used in the design and the closer the project gets to the market introduction date. This is because late design changes are difficult to incorporate if they affect the design of other parts. Supplier involvement can also provide external outsourcing and external acquisition possibilities that reduce the internal complexity of projects (Brown and Eisenhardt, 1995) and provide extra personnel to shorten the critical path for new product development projects (Clark, 1989).

Closely related to the reduction of development time is the reduction of total development costs in terms of engineering hours and prototyping costs as a result of supplier involvement. Suppliers can be more efficient in carrying out design and process-engineering tasks as they are likely to be more specialised in the tasks that they are doing. As a result of carrying out similar tasks and developing expertise that can be used for different customers, they have more opportunities to learn quicker and become more efficient in carrying out a limited set of tasks. The reduction of development costs is therefore made possible by a better resource utilisation (Birou and Fawcett, 1993; Dowlatshahi, 1998; Dyer and Ouchi, 1993). In addition to these benefits that translate into an improvement or deterioration of a specific project's performance, some authors have pointed out a different set of benefits, which are characterised by their long-term and/or strategic nature.

Long-term strategic benefits of supplier involvement

In the long-term/strategic benefits group the most frequently mentioned benefits are (1) *more efficient and effective future collaboration*, (2) *alignment of technology strategies,* (3) *improved access to supplier's technologies,* (4) *a contribution to product differentiation.* We will now investigate what these potential long-term and strategic benefits exactly involve. First of all, some authors state that a long-term relationship in which experience is built up between two partners can result in a more efficient and effective collaboration in future projects. Parties need to adapt to each other before relationships can yield the expected results. Over time they learn more about each other's processes, true requirements and capabilities (Dyer and Ouchi, 1993). In other words, supplier involvement may not yield the expected results in one project, but will provide learning opportunities that will reduce the time spent on certain tasks and dealing with misunderstandings. The experience can also result in better suggestions to improve the design and performance of the part next time. All in all, supplier involvement can lead to a more efficient and effective future collaboration.

A second long-term strategic benefit that a manufacturer may achieve is creating access to suppliers (new) technologies (Monczka, 1997; Bonaccorsi, 1997). Wynstra (1998) argues that having a more permanent access to the technological knowledge of a supplier may be of strategic importance.

A third benefit suggested in the literature is the alignment of technology strategies with key suppliers. Handfield et al. (1999) and Monczka et al. (2000) argue that to be able to exploit new market opportunities in the future, companies need to match technological needs with the technological opportunities that become available in supplier markets. Technology roadmaps provide the opportunity to identify broader technological trends, but also enable discussion about the timing and direction of specific technological progress. Wynstra (1998) views the drawing up and discussing of technology roadmaps as a way to influence the supplier's decisions about the kind of technologies to invest in. We can argue that this influencing activity is important to ascertain the timely availability of technologies that are considered to be important for future product generations. An aligned technology roadmap can therefore significantly benefit a company's competitive advantage by introducing specific technologies and associated functionalities earlier than competitors.

One final strategic and long-term benefit suggested by the academic literature has been the effect of suppliers' contributions on the ability of the manufacturer to differentiate products in the market and to derive a competitive advantage. Rubenstein and Ettlie (1979) and Von Hippel (1988) already pointed out that suppliers are potential sources of innovation. A supplier's new designs and innovations may be especially critical in helping the buyer to differentiate its product in the market place (Dyer, 2000). Therefore, suppliers may have an impact on revenues by increasing the innovativeness of the manufacturer's product proposition in the market (Gadde and Snehota, 2000). This effect actually differs from the more frequently mentioned supplier's contributions to lowering costs resulting from their designs and feedback on manufacturability issues.

2.2.2 Risks of supplier involvement

In addition to the potential benefits of supplier involvement in product development, companies may also run risks when they increase the level of supplier involvement in the development of parts for their final product. These risks can be clustered into five distinct categories: *(1) loss of knowledge or skills, (2) lock-in to suppliers technology, (3) high relationship costs, (4) slow down of product development process. (5) differing aims and objectives, diverging levels of commitment.*
Table 2.2 gives an overview of a number of these risks.

Table 2.2 Potential risks associated with supplier involvement

Author	Suggested risks
Nazli Wasti, Liker (1997)	▪ Protecting and determining intellectual property
Quinn (1999), Nazli Wasti, Liker (1997), Bruce et al (1995)	▪ Diffusion risk for the information, expertise and skills exchanged
Monczka, Trent & Handfield (1998)	▪ Hollowing out of the corporation
Chesbrough & Teece (1996)	▪ Not being able to advance related technologies and design features
Handfield (1999)	▪ Locked into supplier's technology
Bruce et al. (1995), Monczka, et al. (1998)	▪ Loss of ownership / control
Bruce et al. (1995)	▪ Collaboration can be costly
Bensaou (2000)	▪ Costly to develop, to nurture and to maintain.
Laseter and Ramdas (2002)	▪ Slowing down development process
Monczka, Trent & Handfield (1998)	▪ Long lead-times/ capacity shortages
Eisenhardt & Tabrizi (1995)	▪ Supplier involvement in fast-changing environments and less predicTable projects could slow down project cycle time
Chesbrough & Teece (1996)	▪ Lose the ability to pace and influence the technology and to bring to the market on time
Bruce, Leverick, Littler & Wilson (1995)	▪ Expectations of both parties are not always met

(1) Loss of knowledge or skills

Intensive collaboration with suppliers in product development poses potential risks for diffusion of proprietary knowledge and the loss of skills crucial for future product development (Wasti and Liker, 1997; Bruce et al, 1995), thus hollowing out the company (Monczka, 1998). This risk is present in customer-supplier relationships, since a customer may transfer some of what it considers to be non-core knowledge to a supplier. Consequently, the customer can become very dependent on that supplier when this specific knowledge later turns out to be very crucial and when rebuilding this knowledge internally proves to be difficult. Furthermore, a supplier may display opportunistic behaviour when it gains extra skills and knowledge from the customer. This can reduce the control over product development with the prospective threat of the supplier using this knowledge and insight in a non-cooperative way (Bruce et al., 1995). The notion of opportunistic behaviour was introduced in Transaction Cost Theory, which investigates the implications of governing the exchange between the buyer and supplier in order to reduce the risk of opportunistic behaviour (Dyer & Ouchi, 1993; Williamson, 1985). Examples of methods to curb opportunistic behaviour are the use of safeguard mechanisms such as cross-investments or extensive contracting forms implemented by Japanese companies.

(2) Being locked into a supplier's technology

A company that is locked into a supplier technology can be a risk. In fast changing high-tech environments, companies risk becoming locked into a supplier's technology (Handfield et al., 1999). After product introduction the buying company may discover that the technology has now become obsolete or has been replaced by a technology with improved performance characteristics. In a situation of competing technology regimes, involving suppliers earlier on can create an over-dependency. In addition, as soon as the product architecture is partially controlled by the supplier, a manufacturer risks loosing control and the flexibility to implement desired product design improvements. This in turn could result in longer lead-times.

(3) High relationship costs

Relationship costs can become high when involving suppliers intensively (Gadde and Snehota, 2000). Companies that involve a supplier earlier on in the product development process or that collaborate in technology development need to spend more time in bringing together different management styles and budgeting processes (Farr and Fisher, 1992; Bruce et al, 1995). This implies time and effort being spent on co-ordinating the work between two collaborative parties, thereby ensuring the presence of the right information exchange mechanisms on both the strategic and operational levels within the organisation. The relationship therefore becomes more intense and costly to develop and to maintain (Bensaou, 2000).

(4) Slowing down development processes

Involving suppliers can even slow down the overall development process (Bruce et al., 1995; Laseter and Ramdas, 2002). Some evidence has been found in industries subject to high technological and market change that earlier supplier involvement slows down the project (Eisenhardt and Tabrizi, 1995). Laseter and Ramdas (2002) describe a real-life situation in which an exhaust supplier was involved too early before the engine development had stabilised; this resulted in needless design iterations.

(5) Differing aims and diverging levels of commitment

A last important risk associated with involving suppliers in product development concerns increasingly incommensurable objectives between the buyer and supplier. In general, companies establish inter-organisational relationships when they expect them to be beneficial. The presence of a mutual interest is an important incentive to remain committed to the inter-organisational relationship. However, the expectations of the customer and supplier about the way the collaboration will take place and the expected results may change over time or may end up in conflict with each other. Bruce et al. (1995) argue that if there are no review meetings in which possible deviations from planning or expectations are discussed, this will be detrimental to the relationship. Research on the success of strategic alliances has reported changing objectives and diverging levels of commitment between two collaborating partners as being one of the main causes of failure of strategic alliances (Lorange and Roos, 1991). Although Håkansson (1989) argues that inter-organisational relationships always contain elements of harmony and conflict, of mutual and contradictory interests, growing differences can undermine the product development collaboration. As Wasti and Liker (1997) aptly put it, supplier involvement may be ‘risky business’.

2.2.3 Results of supplier involvement

A number of studies have investigated the effects of supplier involvement on speeding up product development projects. The study by Imaï et al. (1985) already found that extensive use of supplier networks had a positive effect on the speed and flexibility of product development in several Japanese industries (such as the automotive, copier, camera, and personal computer industries). Furthermore, a series of studies focusing on explaining the Japanese product development performance advantage in the automotive industry revealed that reliance on supplier networks for component design activities accounted for a significant portion of the development lead-time advantage (Clark, 1989; Wheelwright and Clark, 1992; Nishiguchi, 1994). Bidault and Butler (1995) explicitly mention that some companies in their study slashed the development time by between 30% and 50%. Other research that surveyed larger groups of companies across different industries also found these positive effects on development time (De Meyer and Van Hooland, 1990; Zirger and Hartley, 1997; Gupta and Wilemon, 1998; Ragatz et al., 2002). Burt (1989) reported that Xerox reduced their time and costs by 50% partly due to the closer partnerships with suppliers in product development. Moreover, Asmus and Griffin (1993) reported that a major designer and manufacturer of mechanical equipment saved 80 million dollars on a purchase volume of 1.3 billon dollars annually.

However, there is also evidence available reporting what are, at best, the neutral effects of supplier involvement on accelerating a development project. Eisenhardt and Tabrizi (1995) found that supplier involvement did not accelerate product development in fast changing industry segments such as the mini-computer segment. Hartley et al. (1997;68) found no confirmation that suppliers significantly reduce supplier-related delays and thereby accelerate development projects. They conclude that '*managers should not expect to realise major time reductions by applying early supplier involvement, outsourcing of design responsibility and increased communication with suppliers*'. Instead, they should look for additional ways to reduce the supplier-related delays, such as selecting suppliers with strong technical capabilities. Laseter and Ramdas (2002) report one case at an automotive manufacturer where supplier involvement actually slowed down the development process and added to the project costs. Kessler et al. (2000), although focussing on technology development, argue that external sourcing of technology involvement in the technological development stage is related to slower innovation speed.

If we consider the effects of supplier involvement on the quality of parts and on improving final product performance, once again mixed evidence is available. Nishiguchi (1994) reports that Japanese electronics suppliers have been inspired to innovate wire harnesses (resulting in fewer defects). The new modular design radically reduced the cost, weight, bulk and manufacturing complexity while substantially enhancing reliability (Nishiguchi, 1994). In addition, this supplier-driven innovation helped to accommodate frequent design changes throughout the model cycle of a given car. Studies by Bonaccorsi (1994), Ragatz et al. (2002) and Primo and Amundson (2002) indeed provide evidence that the influence of suppliers actually helps to improve designs and improve the manufacturing performance of the final product. On the other hand, studies of companies in the electro-mechanical, machine tooling and electronics industries by Birou (1994) and Hartley (1994) report both neutral and negative effects on the technical performance of the final product. Moreover, in several cases supplier involvement resulted in higher product and development costs. This contrasts with findings by Laseter and Ramdas (2002), who found positive effects on product costs, and with findings by Clark (1989), and Ragatz et al. (2002), who reported positive effects on development costs. Sobrero and Roberts (2002) provide a more balanced picture in arguing that supplier involvement does not improve both short-term project performance (speed, cost and quality) and enhance long-term capabilities on both sides at the same time. In other words, to achieve certain short-term benefits you may need to make a trade-off against long-term learning benefits. Kessler et al. (2000) also argues that external technology sourcing in the idea generation phase negatively affects the market-place success.

The inconclusiveness of the actual beneficial effects of supplier involvement on product development performance raises questions about the underlying causes. What do we know about supplier involvement as a phenomenon? What organisational and managerial aspects have been distinguished? We therefore further examined the emerging interest in this phenomenon by analysing previous studies on supplier involvement in terms of the topics, the main dimensions studied and the conceptual approaches used. We have identified at least five distinct clusters of supplier involvement dimensions and conceptual approaches. We will now investigate the common notions in each of these clusters of studies. Together they provide a set of possible explanations and clues about the effective ways to involve suppliers in product development.

2.3 Cluster 1: Supplier involvement as an outsourcing of product development

The first notion that connects numerous studies investigating the role of suppliers in product development is viewing supplier involvement as a form of outsourcing. These studies have been inspired by the debate within the strategic management literature on how companies can improve their business performance by reconfiguring the set of activities carried out internally and the resources they control internally or acquire externally. The discussion draws on different theoretical perspectives such as Transaction Cost Economics and the Resource Based View of the company. This body of literature argues and provides evidence that external companies can be far more specialised and therefore more efficient in certain activities. Hence, the choice to transfer or to outsource these previously in-house activities to external companies may be a good way of achieving improved business performance. The underlying decision as to which activities to keep in-house and which ones to outsource involves determining the most effective and efficient boundaries of the company. The outsourcing decision has long been considered to be of strategic importance (Quinn, 1992; Poppo and Zenger, 1998) in determining the future course and alternatives of companies and in affecting their competitive position. In Chapter 1 we provided evidence that companies in manufacturing-intensive industries, such as the automotive and electronics industries, have started to increasingly outsource part of their manufacturing activities to external suppliers. Early studies in Operations Management and Purchasing literature particularly highlighted the importance of the decision to keep manufacturing activities internally or buy the manufactured components from external suppliers. This particular outsourcing decision was often referred to as the 'make-or-buy' decision and has been studied in-depth (Ford and Farmer, 1986).

However, the outsourcing decision was limited to manufacturing in terms of make-or-buy decisions. Several studies have pointed out that automotive and electronics companies in Japan increasingly started to solicit input from different suppliers and transfer responsibilities for several part development activities to their network of suppliers. What was revealed, in fact, was that companies were engaging in a form of outsourcing but extended it to product development activities. An eye-opener was the distinction between multiple levels of supplier involvement in the customer's product development process (Burt, 1989; Clark, 1989; Birou and Fawcett, 1994). Clark (1989) identified three main categories of parts indicating different balances of development effort and specification freedom left to the supplier. In order of increasing development responsibility and influence on the specifications, these categories are: (1) *detailed controlled parts,* (2) *black-box parts* and (3) *supplier proprietary parts*. Using a slightly different categorisation, Handfield et al. (1999) identify: (1) *black-box,* (2) *grey-box* and (3) *white-box parts*. Bidault and Butler (1995) distinguish three development situations exhibiting the same differences in possible degrees of influence and development responsibility held by a supplier: (1) *design supplied,* (2) *design shared* and (3) *design sourced*. These categorisations were inspired by the practices of Japanese manufactures and avoided using the binary outcomes such as simple make-or-buy decisions. They draw our attention to the possible task divisions through which manufacturers and suppliers can organise product development.

An additional new element in the outsourcing of different development tasks was the notion of consciously contacting suppliers during earlier product development phases (Wasti and Liker, 1997; McGinnis and Valopra, 1998). Handfield (1999) refers to different moments of possible involvement starting as early as the idea generation phase and as late as the prototype, build, test and production ramp-up phase. The argument for early involvement was the increased opportunities for design improvement and suggestions of manufacturability given that as much as 70% to 80% of the product and life cycle costs and 80% of the final product's quality performance are determined in the initial design phases of a product (Dowlatshahi, 1992; Van Weele, 1999). Late involvement, that is, as soon as the overall project progresses from the concept to the later stages of product development, would rapidly reduce these opportunities. The necessity for earlier supplier involvement was driven by the trend to adopt more parallel execution of product and process engineering activities. Since this response was aimed at compressing the overall product development time, the input from suppliers was needed earlier.

Our view is that these studies provide an important anchor point in the research on supplier involvement in product development. They developed the notion that differentiating between supplier roles in terms of the supplier's development responsibility and the moment of involvement are important decision variables to improve product development performance. They also provided an important starting point to further understand whether and how different levels of involvement required different governance structures.

2.4 Cluster 2: cooperative relationships as a condition for effective supplier involvement

A second notion that several studies share is the close and cooperative nature of buyer-seller relationships as a condition for effectively involving suppliers in product development as opposed to adversarial approaches (Sako, 1993; Bruce and Leverick, 1995; Bidault et al. 1998). Empirical evidence suggests that some successful companies who adopted supplier involvement engaged in distinctly intensive collaborations with their suppliers. The knowledge on the rationale and the specific characteristics of these collaborative relationships emerged from streams of literature in the strategic, innovation, purchasing and marketing areas focusing on strategic alliances and on buyer-seller relationships.

Studies within strategic management and innovation management literature paid increasing attention to the role of cooperative strategic alliances as a particularly effective way of organising R&D and technology development activities. Although these alliances did not focus on suppliers as one of the alliance partners per se, they did point to the increasing extent of cooperation in the areas that strongly affect product development capabilities. R&D alliances are based on a non-equity contractual relationship, in which two companies share their R&D activities and resources (Hagedoorn, 2002). In other words, they bring in their own resources for a specific purpose without setting up a new company. An increasing number of alliances involved technology or R&D alliances between non-related companies or competitors (Narula and Hagedoorn, 1999). However, some authors also investigated the strategic alliance concept in the context of collaborative product development between the manufacturer and suppliers (Bruce et al., 1995). Within the purchasing and marketing literature, a particular interest emerged in studying cooperative buyer-seller relationships as an effective way to improve several processes between companies. Several studies on buyer-supplier relationships revealed that Japanese companies were particularly successful in outsourcing component production and assembly activities because they adopted a specific relationship model with their suppliers. The close relationships with suppliers appear to explain some of the cost and quality advantages that gave Japanese manufacturers a competitive edge (Dyer and Ouchi, 1993) over Western companies, who had a more adversarial type of relationship with their suppliers. Adversarial relationships were characterised by a strong cost focus in which suppliers were considered to be dispensable; numerous suppliers had to fight for their contract for each specific component through a competitive bidding procedure. This created a hostile atmosphere between the buyer and supplier, or at least an atmosphere not conducive to further improve processes between the buyer and supplier and to share quality and cost benefits. In contrast, the cooperative relationship mode that was observed at Japanese companies enabled several joint efforts regarding improving production and logistical processes. This type of cooperative relationship has become known as the 'Partnership mode' (Spekman, 1988; Johnston and Lawrence, 1988; Mohr and Spekman, 1994) or 'Relational contract exchange mode' (Ring and Van de Ven, 1992; Dwyer et al, 1987).

Although the collaboration domain in this body of literature did not initially focus on product development specifically, the role of suppliers in product development increasingly became the subject of research within this context of the buyer-supplier partnerships. The studies on Japanese buyer-supplier relationships are considered to be important benchmarks regarding the specific relationship characteristics and are regarded as success-factors. Ellram and Hendrick (1995; 41) defined a 'partnership' as follows:

> *'A 'partner' is defined as a company with whom your company has an ongoing buyer-seller relationship, involving a commitment over an extended time period, a mutual sharing of information and a sharing of risks and rewards resulting from the relationship.'*

Several studies on buyer-supplier partnerships and strategic alliances provided insights into these specific characteristics. We have also looked at the literature on inter-company collaboration in general (e.g. Moss-Kanter, 1994; Ring and Van de Ven, 1992; Schrader and Sobrero, 1998). Table 2.3 provides an overview of frequently-mentioned characteristics and indicates whether the studies focused on the context of the overall buyer-supplier relationship or specifically on the context of collaboration in product development. In general, the collaboration is based on specific practices that enable intensive communication between both partners. A mechanism that is frequently mentioned is the (temporary) 'co-location of supplier representatives (e.g. engineers) who join a project team' (Lewis, Slack and Twigg, 2001; Monczka, 2000; Lamming, 1994). The rationale is that short communication lines and face-to-face communication facilitate learning and speed up design iterations. With regard to the content of intensive communication, the sharing of costs and technological information appears to be a crucial ingredient in supporting the outcome of a collaboration. Authors point to the need for the enhancement of trust for intensive collaboration to take place or to continue. The sharing of rewards and risks, striving for a mutual dependence, mutually assisting each other and jointly solving problems seem to enhance the trust between two partners (Mohr and Spekman, 1994; Ragatz et al., 1997). Several studies further argue that without clear and shared goals defined at the outset and a committed management on both sides, more opportunities for conflict are built into the relationship. Although it seems that these studies portray successful buyer-supplier relationships in product development as being purely cooperative in nature and based on a win-win situation, later contributions 'corrected' this image. Win-win does not necessary mean an equal exchange of benefits (Whipple and Frankel, 2000) (or input), but comes down to 'fair dealing'. 'Fair dealing implies that all companies receive benefits proportional to their investments' (Ring and Van de Ven, 1992; 94).

Table 2.3 Supplier involvement success factors and relationship characteristics

Success factors	Studies on general buyer-supplier/ (intercompany) relationships	Studies on collaborative product development
▪ Top management commitment	Spekman et al. (1988), Mohr and Spekman, (1994), Whipple and Frankel (2000)	
▪ Trust	Spekman et al. (1988); Ring and van de Ven (1992), Sako (1993), Mohr and Spekman, (1994),	
▪ Win-win situation/formalised risk and reward sharing/perception of equality in contributions	Ellram (1995)	
▪ Shared education and training	Ellram (1995)	
▪ Conflict resolution through joint problem solving	Dyer and Ouchi (1993), Mohr and Spekman, (1994),	Bozdogan (1998), Monczka (1998), Ragatz, (1997)
▪ Formal supplier assessment/selection		Ragatz (1997)
▪ Compatible partners in terms of operational philosophy and problem solving ability	Moss-Kanter (1994), Whipple and Frankel, 2000, Moss-Kanter (1994)	
▪ Shared significant customised investments in plant, equipment and personnel	Dyer and Ouchi (1993), Moss-Kanter (1994)	Ragatz et al. (1997) Monczka et al. (1998)
▪ Mutual assistance and focus on total cost and quality	Ellram (1995)	
▪ Shared goals/ joint agreements on performance measures	Mohr and Spekman, (1994); Moss-Kanter (1994); Whipple and Frankel, (2000);	Ragatz, (1997)
▪ **Relationship characteristics**		
▪ Intensive and regular sharing of technical and cost information	Dyer and Ouchi (1993), Mohr and Spekman, (1994), Moss-Kanter (1994)	
▪ Long-term nature	Spekman et al. (1988), Moss-Kanter (1994), Moss-Kanter (1994)	
▪ Frequent and planned communication	Dyer and Ouchi (1993)	
▪ Co-location of supplier personnel at customer's project team/premises		Lewis Slack and Twigg, 2001; Monczka, 2000; Lamming, 1994

Moreover, both cooperative and competitive elements appeared to co-exist in buyer-supplier relationships according to Gadde and Håkansson (2001), Nishiguchi (1994), Lamming (1993) and Hines (1994). Japanese companies in particular have built competitive elements into their sourcing strategy. They do not rely on single relationships with suppliers for all of their components, neither do they involve one supplier in product development for a particular component. For example, Toyota has been found to adopt design contests before deciding on which supplier is going to be awarded the contract to further develop and deliver the part during its life cycle. The cooperative aspects of their relationship appear in practice by establishing a long-term relationship with both suppliers during which the automaker provides assistance to the weaker of the two suppliers. It relies on experience curve pricing taking into account that a reduction in supplier prices must be accompanied by cost reduction (Dyer and Ouchi, 1993).

This body of literature has provided valuable knowledge about the characteristics and practices that constitute success factors when engaging in intensive relationships with suppliers (in product development). Supplier involvement requires a certain degree but not an exclusive degree of cooperation. One of the limitations of this cluster of studies is that they abstract these factors to the general buyer-supplier relationship. This implies that they do not focus on the dynamic and evolving nature of relationships. Unfortunately these studies do not give us the key to the black-box of how the buyer and supplier make relevant decisions internally, nor do they give us sufficient insight into how such relationships are managed in development projects.

2.5 Cluster 3: Managing supplier involvement through differentiated relationships and collaborations

As we have seen in the previous sections, during the eighties and nineties a significant body of literature focused on the value of outsourcing and the role of inter-company collaboration as the most rewarding way of governing the exchange and thereby improving business processes. Other studies particularly addressed the managerial aspects of supplier involvement by introducing the notion of differentiation. The main argument is that supplier involvement in product development can be managed more effectively when general buyer-supplier relationships and collaborations in projects are differentiated in terms of management attention, resources and co-ordination mechanisms.

2.5.1 Differentiating buyer–supplier relationships

One of the most powerful insights developed within the purchasing and marketing literature during the eighties stated that companies need to distinguish between different types of customer or supplier relationships. The core argument was that both customer and supplier relationships differ in terms of the value and the risk they bring in to the exchange. Consequently, authors such as Kraljic (1983), Bensaou (2000) and Anderson and Narus (1990) proposed that customers and suppliers should manage their relations in a differentiated fashion, depending on the specific combinations of value and risk present. A number of sources of risk have been mentioned, such as product novelty, supplier power, rate of technological change and available supplier capabilities (Olson and Ellram, 1997; Bensaou, 2000). Some of these risks are typically connected to the notion used in transaction cost theory that parties are inclined to behave opportunistically if they are given the chance to do so. Differences in the balance of power may create incentives to behave opportunistically. Therefore, the situations in which this risk is higher must be managed differently than low-risk situations. Specific measures need to be taken to reduce risks and to leverage the potential value of the relationship. In terms of management characteristics, Bensaou (2000) suggests that the management of the relationships differs in terms of (1) *information sharing practices*, (2) *boundary spanner's job characteristics*, and (3) *the social climate within the relationship.* Alternatively, Olson and Ellram (1997) suggest that the amount of resources devoted to managing a relationship and the specific risk reduction strategies (e.g. a multiple sourcing or partnering strategy) are actually not only influenced by the power/risk balance but are also affected by the attractiveness of the supplier and strength of the relationship. As such, these portfolio models have provided a more general tool for analysing buyer-supplier relationships, for helping to allocate specific levels of resources, and for identifying appropriate risk reduction strategies. This idea of differentiating the management of supplier relationships was later connected to the management of supplier involvement in product development projects.

2.5.2 Managing differentiated supplier roles in product development

One of the first notions, described in section 2.4, was the idea that successful supplier involvement is characterised by different forms of outsourcing based on the degree of supplier development responsibility and the moment of supplier involvement (Clark and Fujimoto, 1991; Bidault and Butler 1995). A growing number of studies started to study supplier involvement by connecting the different roles they can play with appropriate co-ordination mechanisms to manage the relationship with suppliers in product development.

For example, Kamath and Liker (1994) discuss several managerial implications of four different roles suppliers played during product development, such as in terms of the direction and amount of communication between the buyer and supplier. The underlying reason for focusing on communication characteristics is the view that companies can increase the performance of their product development tasks if they find appropriate patterns and mechanisms to deal with different levels of uncertainty surrounding a particular collaboration in product development. Several studies that investigate buyer-supplier collaboration in product development draw on 'information processing theory' (Tushman and Nadler, 1978; Galbraith, 1973; Daft and Lengel, 1984) to provide managerial implications on how to structure the relationship. These studies view product development as a set of interdependent tasks that is surrounded by different levels of uncertainty. This uncertainty can be expressed in terms of the amount of information needed to fulfil a particular task and the availability of that information; the larger the gap, the higher the uncertainty. Companies striving to minimise that gap should choose the most effective set of communication and co-ordination mechanisms that provide the information required by the task.

The study by Bensaou and Venkatraman (1995) suggests a typology of five different buyer-supplier relationships, which is based on this information processing perspective. These types are characterised by varying levels of uncertainty surrounding the relationship and differ in terms of their information needs to perform the divided buyer and supplier development tasks. These different relationships are therefore connected to a differentiated use of structuring (e.g. number of communication channels), process (e.g. conflict resolution, commitment) and technological mechanisms (e.g. scope of the use of IT-technologies) for inter-organisational co-ordination. The higher the uncertainty and information needs, the more these relationships have to resort to a variety of co-ordination and communication mechanisms with high information carrying capability. This typology addresses the role of supplier involvement in product development, although not exclusively; it applies equally to buyer-supplier relationships.

In contrast to the focus on differentiating general supplier relationships, some authors argue the management of supplier involvement should be studied with the specific project and task characteristics in mind. For example Lakemond (2001) provides an interesting complementary perspective to the dominant relationship view. She develops a co-ordination typology for managing supplier involvement that links the *project's* task characteristics with specific intra-organisational and inter-organisational co-ordination mechanisms. Her argument is that dependencies arising from different product development activities carried out internally and externally and from diverging perspectives require co-ordination. In situations where a high degree of interdependence exists between tasks, she proposes the use of 'project integration co-ordination'. The supplier (virtually) becomes part of the development team discussing concepts, interfaces and tolerances with them. In 'disconnected sub-project co-ordination' the supplier task is uncoupled from the overall project task. The supplier carries out the activities largely independently as part of a sub-project that requires limited interaction between the development team and the supplier. Ad hoc co-ordination of the involvement of suppliers provides incidental co-ordination of tasks when the need arises.

The study by Wynstra and Ten Pierick (2000) focuses solely on the managerial implications at the level of the specific development task. They propose a portfolio instrument that distinguishes between different collaboration situations in development projects. The four collaboration types were derived from differences in terms of the level of supplier development responsibility and the degree of development risk that characterised the collaboration in the specific project. The portfolio is accompanied by four different sets of communication characteristics, which can therefore be used as a managerial tool to determine and implement the appropriate communication characteristics. A practical and useful notion is that engineers typically follow a certain order in developing parts depending on different risk factors such as the presence of new technology or the interface complexity. In order to reduce these risks (in time), the timing and intensity of communication between engineers of buyer and supplier may need to be differentiated. High involvement collaborations in high risk situations may require both early and intensive communication patterns and mechanisms. However, low involvement but high risk development situations may also require early communication; this will merely be a limited exchange of critical design or cost information, after which both parties limit their interaction. This distinction allows a more efficient and effective use of internal and external management attention and development resources.

Using a similar approach, Sobrero and Roberts (2002) also came up with four types of communication behaviours of buyers and suppliers, which are connected to various levels of supplier development responsibility and task characteristics (e.g. interface interdependency). Their study goes further than underlining the importance of balancing specific structuring choices with the characteristics of the task in hand (i.e., the level of supplier development responsibility and the interdependence). They argue that building communication-intensive relationships with suppliers is costly and only offers pay-back opportunities if they are used to improve the manufacturer's knowledge base rather than merely reduce internal development costs through subcontracting. In fact, a trade-off exists between achieving short-term efficiency and learning through intensive interaction.

The aforementioned group of authors particularly addressed organisational collaboration and the managerial structuring decisions from an 'information processing perspective'. Other authors who addressed some managerial aspects of supplier involvement have used different perspectives such as the resource dependence perspective and/or transaction cost perspective. A number of authors combine a view of companies being dependent on the resources present in their external environment with a network view of coping with supplier relations. We present two examples that provide valuable insight into the complexity and ways of organising supplier involvement in product development.

First, Von Corswant (2002; 136) argues that the management of supplier involvement requires the management of dependencies between four different types of resources: products, business units, business relationships and production facilities. He neatly demonstrates the high complexity arising from different types of technical and relational dependencies that need to be considered when organising product development and supplier involvement (Von Corswant 2003; 178). Companies should carefully examine how to keep reducing the complexity of dependencies at different points in time (e.g. during the development project). The boundary of the team (e.g. representation of suppliers and other function on the development team) and the definition of the product architecture are particularly important in facilitating interaction within the team and between suppliers.

Secondly, Araujo et al. (1999) come up with a typology for managing dependencies in product development with suppliers by focusing on the organisational interface. They state that the management of supplier relationships is driven by two important questions, which touch upon two interdependent issues: (1) 'What resources should be controlled internally and what resources should be accessed externally?' and (2) 'How should the buyer access the type of resources?' These questions relate to the previously-mentioned make-or-buy decision, but specifically investigate how to create access to those resources, which the company decided or is forced to source externally. They argue that in order to access the supplier resources, companies need to develop different types of interfaces. They suggest a typology of four different interfaces through which resources between the buyer and supplier can be related.

(1) *Standardised interfaces* are used when the knowledge of use and of production are unrelated. They apply in so-called arm's length relationships.
(2) *Specified interfaces* are used in the case of customised products in which the supplier needs directions from the customer about the product and production characteristics. This interface applies in cases where the customer subcontracts production and the supplier is viewed as an extension of this function.
(3) *Translation interfaces* apply when the customer provides characteristic based on the function of the product in its user context. The customer supplies functional specifications to the supplier, who takes a greater responsibility in the development of the product.
(4) *Interactive interfaces* are appropriate in contexts where the user and producer use each other's knowledge in an dialogue setting to develop the specifications.

Araujo et al. (1999) mainly describe the connection between the buyer and supplier needed to combine resources during product development. They describe slightly different supplier roles than those suggested by Kamath and Liker (1994), by using a different concept that emphasises the connection between two resource owners via a distinct interface. They also juxtapose those situations in which suppliers are used as an extension of the production function with situations where suppliers are highly involved in product development. Similarly to Sobrero and Roberts (2002), they provide a convincing argument that resource interfaces may have different productivity (i.e. efficiency) and innovativeness advantages and disadvantages. What appears to be important is that companies have to consider what type of benefits they want from suppliers and adopt the interface that supports the type of benefits pursued. In other words, the way in which a company co-ordinates the activities with suppliers in product development has implications on the type of potential benefits to be captured.

The previously-mentioned studies provide important additional insights into how to manage supplier involvement from a contingency perspective. The main notion is that buyer-supplier relationships in product development need a differentiated management approach. Such approaches are described in terms of the conditions that companies may need to strive for, and in terms of the communication behaviour and mechanisms that allow effective supplier involvement to take place. Furthermore, some of the studies use typologies or portfolio models to differentiate between the appropriate managerial approaches for general buyer-supplier relationships or specific collaboration situations. The last perspective provides the most concrete clues of how to structure and co-ordinate the process of combining resources internally and externally with suppliers in product development. The limitation of these approaches is that they barely address how such companies make a number of critical decisions before and during projects (e.g. selecting suppliers and determining the final degree of supplier involvement). Moreover, supplier involvement is managed by different departments and actors. In such studies these issues are therefore only addressed to a limited extent using an inter-organisational buyer-supplier relationship and collaboration perspective in the project context.

2.6 Cluster 4: Purchasing involvement in product development

We have identified a fourth cluster of studies that look at the management of supplier involvement from the perspective of an internal actor. In relation to managing supplier involvement, a large number of studies focus primarily on the role of the purchasing department/buyers in the product development process. As a result, they have adopted an internal actor perspective on managing supplier involvement. Few other actors such as the R&D or manufacturing departments are studied in the context of supplier involvement.

The purchasing department can fulfil different roles in product development. The interest in analysing the role of purchasing in product development is based on the partial overlap in the type of contributions they can directly or indirectly make by identifying and bringing in suppliers who eventually provide the contributions that improve the product development performance. These studies identified potential activities, related directly and indirectly to involving suppliers in product development, which the purchasing department can carry out. In addition, several studies focused on the conditions that enable effective purchasing involvement. Examining the potential roles, activities and conditions for involving the purchasing department in product development may therefore enrich and deepen our understanding of relevant managerial dimensions enabling effective supplier involvement.

2.6.1 The role of Purchasing in product development

A growing number of studies have argued the potentially beneficial role of the purchasing department as an internal actor in improving product development performance (Farmer, 1981; Axelsson and Håkansson, 1984; Burt and Soukup, 1985; Stuart, 1991; Dowlatshahi, 1992; Guy and Dale, 1993; Atuahene-Gima, 1995; Nijssen et al., 2002). In a study by Fearon (1989), it was found that 31% of the purchasing departments have seen an increase in product development responsibility since 1980. Traditionally, their involvement was largely operationally oriented and limited to the later stages of the purchasing process in terms of contracting, ordering, evaluating and after care of supplier relationships. However, Handfield (1993) argued that purchasing managers could significantly contribute to lead-time reduction efforts, particularly in terms of reducing late supplier deliveries and fewer material defects by working closely with a small number of certified suppliers.

The contributions of purchasing to product development may be linked to three general roles that the purchasing department plays according to Axelsson and Håkansson (1984) and Wynstra (1998). They suggested that purchasing could adopt a *rationalisation*, *structure* and *development role*. The first role is mostly related to various measures of reducing direct and indirect material costs and internal production costs, such as adapting the final product to reduce the supplier's production costs. The *structure role* of purchasing relates to handling the company's supplier network, in terms of managing the degree of dependency. It can do this by increasing or decreasing the number of possible suppliers, for example, or influencing the degree of standardisation of suppliers' products. The *development role* concerns systematically matching the company's technological development with the development and management of suppliers and the supplier-network. It can do this by motivating suppliers to develop products that the company wants, for example, or by participating in internal discussions on the scope of in-house technical development.

O'Neal (1993) argued that the role of the purchasing department can lie in actively acquiring, assimilating, digesting and sharing information on new and forthcoming supplier developments. This would allow purchasing to provide a window on new technologies, materials and components that suppliers have developed. Furthermore, the interfacing of purchasing with marketing and engineering may lead to the identification of new product possibilities. This role seems to be very similar to the aforementioned 'development role'. Purchasing has become a type of liaison and information processor, connecting the internal and external resources. Birou and Fawcett (1994) refer specifically to purchasing's facilitating role once the decision to involve suppliers has been made, in terms of identifying those suppliers who will become part of the team and then managing the buyer and supplier interface. In other words, they are a coordinator or relationship manager. Other activities include (Birou and Fawcett, 1994; 13-14):

(1) cataloguing suppliers' technical expertise,
(2) promoting earlier supplier involvement,
(3) building stronger buyer-supplier relationships that will be conducive to seeking greater supplier investment in both technology and R&D,
(4) developing a committed environment that will enable suppliers to be more creative and to accept more risks,
(5) and facilitating better and more consistent communication.

In contrast to the more long-term and facilitating role of the purchasing department, Dowlatshahi (1992) identified seven collaboration areas with product design teams during early design phases of a development project. The following operational activities were identified: (1) developing specifications, (2) developing interchangeable parts, (3) part standardisation and simplification, (4) value analysis, (5) part substitution, (6) part exclusions, and (7) miscellaneous contributions. The roles and various activities of the purchasing department suggest that it can be an important player in the company's management and utilisation of suppliers' expertise in product development. However, a number of conditions need to be present before a purchasing department can effectively fulfil these roles.

2.6.2 Conditions for effective purchasing involvement in product development

In addition to the focus on purchasing involvement, studies have also looked into the way the purchasing department is structured and integrated in the project team, and the human resource and information technology-related factors. Wynstra (2001) suggested that purchasing involvement depends on the organisation of the purchasing department which is supportive to the required communication and co-ordination in product development. A cross-functional organisation is argued to particularly improve the communication and facilitate the timely evaluation of different suppliers (Mendez and Pearson, 1993; Monzcka, 1998; Wynstra, 1998; Handfield, 1999). Examples of structural arrangements/mechanisms that support an effective role of purchasing in product development include formal project team representation and the presence of an initial purchasing unit within the overall department. For example, appointing purchasing professionals at the start of the project, in addition to operational buyers, helps the department to focus its role during the early phases of product development. Furthermore, different purchasing functions can be created that vary in their technical orientation and knowledge or their co-ordinating role (Lakemond, Van Echtelt and Wynstra, 2001). For example, some manufacturers appoint purchasing engineers who are integrated on a permanent basis, while other companies use project buyers to co-ordinate and channel all purchasing issues related to a development project. The contributions of creating such positions are related to the different needs of organisational co-ordination and the technical/ commercial knowledge.

Human resources also appear to be a critical factor in determining the effectiveness of purchasing involvement. Many companies traditionally face a situation of different and often conflicting, orientations between the purchasing and development departments (Dowlatshahi, 1992). In particular, the traditionally strong operational and commercial orientation that buyers and the whole department possess (or used to posses) does not easily link up with the largely technically-oriented R&D representatives. Since Purchasing is a department that has interfaces with many different actors, such as suppliers, R&D and Manufacturing, its employees must develop combinations of technical and commercial know-how and skills that allow them to interact with them effectively. Several human resource factors can help to overcome these differences. Purchasing employees can be involved more effectively if they have been selected based on criteria such training and education levels, or based on their experience gained through further in-company training and rotation between different departments (Burt and Soukup, 1985; Anklesaria and Burt, 1987; Atuahene-Gima, 1995; Wynstra, 1998). For their involvement to be effective it is important that the other actors perceive these skills (Atuahene-Gima, 1995). A lack of credibility of individual buyers or of the overall role of the purchasing department can be an important barrier to the effective utilisation of supplier's expertise in product development.

The roles and conditions for effective purchasing involvement contribute to our understanding of which elements need to be taken into account when managing the supplier base and collaborations in product development.

2.7 Cluster 5: Activity/process models for analysing supplier involvement

Besides the strong focus on Purchasing involvement, a limited number of studies have focused on activity/process based models that adopt a broader perspective to managing supplier involvement than the role of the purchasing department. We have identified five different models associated with managing supplier involvement in product development that list and cluster different (improvement) processes and managerial activities. We also briefly discuss a special conceptual model taking a network perspective on the role of suppliers in product development.

The 'Early Supplier Involvement Framework' proposed by Dowlatshahi (1998), delineates several activities for various involved actors during manufacturer-supplier collaborations in the product development process. Actors include, Design, Procurement, Manufacturing and suppliers, and each actor has a typical activity portfolio where it takes the lead. The Design representatives carry out activities such as determining the customer and product function usage, determining material requirements and raw material costs, or determining quality targets. Procurement has a leading role in areas such as the analysis of make-buy decisions, determining the order frequency and negotiating prices, transportation costs and terms and lead-times, etcetera. Suppliers lead in implementing the standardisation of raw materials, improving quality controls at their factory, determining R&D investments and so forth. Finally, Manufacturing focuses on defining manufacturing processes, determining the size of production runs and evaluating set-up times etc. An important observation is that all actors carry out interrelated tasks that reflect both technical and commercial trade-offs typically encountered during a product development project. Dowlatshahi argues that, 'using this conceptual framework as well as a formal cross-functional product development team serves as a systematic problem-solving mechanism where the constraints, contributions and concerns of functional areas are considered before the design is finalised' (Dowlatshahi, 1998; 150). The scope of Dowlatshahi's framework is limited to the typical tasks that relevant actors in a development project need to carry out.

Whereas Dowlatshahi (1998) proposes typical task divisions between internal departments and the supplier during product development, Evans and Jukes (2000) developed a conceptual model that delineates the processes to *improve* co-development relationships between OEM manufacturers and suppliers. It has been developed after research based on action research and focusgroups. The core argument is that organisations of manufacturers and suppliers need to be aligned in terms of development processes. The model suggests that the alignment of processes proceeds in a series of four steps, supported by joint team working. Evans and Jukes (2000) put more emphasis on the inter-organisational improvement and adaptation processes without explicitly identifying the tasks of the individual departments. The model therefore provides an overall framework that is complementary to the prescriptive and descriptive activity or process frameworks.

In contrast, Takeishi (2001) adds an internal and inter-organisational co-ordination and communication perspective when analysing supplier involvement. Takeishi contends that effective component development (*higher component development performance*) is associated with an automaker's external co-ordination with a supplier (*problem solving and communication*), internal capabilities (*internal co-ordination and knowledge*), and the nature of automaker–supplier relationships. He controls for the supplier's capability, the nature of the task, and other factors.

His main conclusion is that outsourcing does not work effectively without extensive internal effort. To gain competitive advantage from outsourcing, managers should '*Ask not what your supplier can do for you; ask what you can do with your suppliers', (Takeishi, 2001; 419).* Takeishi (2001) initially focuses on a general level of abstraction of development activities[4], and later on provides a more detailed and practical overview of typical activities during several project stages to develop the component according to component quality targets. However, the overview is limited to an exemplary delineation of a typical automaker, supplier and joint tasks in the automotive industry. In general, the framework provides a valuable contribution to the interplay between external co-ordination and the need to also invest in internal co-ordination when managing the collaboration with a supplier. However, its limitation is that it does not explicitly focus on the interplay between internal (strategic) decision-making processes that indirectly support supplier involvement or on the long-term effects of collaboration.

Wynstra (1998) developed an activity-based framework similar to Dowlatshahi's framework. The framework delineates the managerial activities argued to contribute to the effective and efficient purchasing involvement in product development. He defined purchasing involvement as: '*Contributing knowledge, taking part in managerial processes and participating in decisions with regard to product development, from a perspective of purchasing, i.e. striving towards optimal total product costs, well-balanced dependencies on suppliers, and an optimal technological match with suppliers' (pp.65).*

Although the name of the framework points to the purchasing department, it takes a broader perspective. As in Takeishi's framework, Wynstra does not link/assign the activities to specific actors in advance (e.g. departments or individuals). The activities are grouped into four different management areas, with each area focusing on different aspects of managing supplier involvement. The four areas are:

1. <u>Development Management</u> focuses on establishing the general policies and guidelines for supplier involvement in product development, and the technological areas in which to collaborate;
2. <u>Supplier Interface Management</u> focuses on building an infrastructure or network of suppliers that can contribute to product development processes; it concerns the ongoing management of supplier relationships.
3. <u>Project Management</u> is primarily concerned with managing the involvement of suppliers in specific development projects;
4. <u>Product Management</u> focuses on defining the actual product specifications within a development project.

In contrast to the previous authors, Wynstra identifies additional long-term and strategic tasks in the Development and Supplier Interface Management areas that are required to support the management of supplier involvement in development projects. Moreover, the explicit incorporation of possible conditions that affect the ability of the company to effectively and efficiently carry out the activities in the four management areas constitutes a broader conceptualisation of the management of supplier involvement than in any of the previous

[4] Which he conceptualised as the internal co-ordination, the problem solving pattern and communication behaviour.

models. These conditions are labelled as enabling factors. They include (1) the organisation of the purchasing function supporting its effective and efficient involvement in product development, (2) the exchange and recording of information facilitating the content and process of the development process and lastly (3) the availability of adequate human resources. In contrast to the previous authors Wynstra (1998) adopts a contingency perspective, recognising the possible differences in the need and form of managing supplier involvement. He identifies a number of structural characteristics that function as contingency factors such as, (1) the size of the company, (2) the dependence of the company on its suppliers and (3) on R&D and (4) the specific production type characterising the industry.

The next model that has been identified is the framework developed by Monczka, Handfield, Scannell, Ragatz and Frayer (2000). They propose a process/activity model that distinguishes a Strategic planning process and an Execution process for integrating suppliers into product development. Each process consists of several activities. In the strategic planning process, current and future needs regarding product requirement technologies and internal and external capabilities are identified; steps are subsequently undertaken to establish a strategically aligned world-class supply base and a bookshelf of viable technologies and suppliers ready to be integrated in development projects. Monczka et al. (2000) identify another five steps in the supplier integration execution process that follow the strategic planning process and should result in successful supplier integration. These activities are related to determining the supplier's role and setting targets and, secondly, to sharing information and learning from past experiences. In a similar way to Wynstra (1998), he suggests that different steps are carried out and decisions are taken at different organisational levels to effectively involve suppliers in product development. Although Monczka et al. (2000) identify barriers to integration and strategies to overcome them, they are not conceptualised in the process-based model.

Finally, we identify a specific approach that has been used to study inter-company relationships and technological collaboration, known as the Industrial Network Approach. Although its scope actually goes beyond the specific topic of supplier involvement in product development, its notions can be seen as an overarching perspective to studying the phenomenon. The conceptual model points to the difficulties of managing interdependencies between the actors, their activities and resources as part of a network of relationships that affect each other (Håkansson, 1987; Axelsson and Easton, 1992; Håkansson and Snehota, 1995). They argue that product development is constrained by the interdependencies that are present between, and created directly and indirectly by, multiple buying and supplying companies. These interdependencies are present due to the three different layers that exist in business relationships. First, relationships link the internal *activities* (e.g. assembly, engineering and design) of actors. Moreover, a relationship *ties together resources* that are adapted, combined and are controlled by the involved parties. *Actor bonds* are developed as the relationship evolves, which affect how the actors perceive and act towards each other. Activity links, resource ties and actor bonds constitute the content and characteristics of a relationship. However, they do not exist in isolation in a relationship between one buyer and supplier but are connected to other dyadic relationships, together forming a network structure. The degree of discretion in truly managing supplier involvement is therefore considered to be limited because of the existence of non-controllable actions, resources and activity links of other companies that affect a given dyadic relationship. As such, the Industrial Network Approach mainly emphasises the links between actors, resources and activities. Its general message is a powerful one. If as a researcher and as a company one does not look beyond a single supplier and does not try to understand dependencies elsewhere in the network, one may overlook opportunities for accessing valuable resources (technologies, knowledge) or may form a 'road block' to effectively involving suppliers in product development.

We have compared the models in terms of the identification of activities and/or processes, the level(s) and unit(s) of analysis, the type of actor perspective, the identification of contingency and success/enabling factors and finally in terms of the investigation of supplier involvement performance. In Table 2.4 we have summarised the characteristics of the activity and process-based models. What activity and process models have in common is their approach of delineating and examining critical decisions or activities carried out by (possibly) different internal departments and/or suppliers. The industrial network model provides a more general conceptual model rather than a concrete framework to examine concrete (managerial) activities and decision-making. It therefore does not provide an 'internal decision-making perspective' on the management of supplier involvement in product development. As such, the model is no better or worse than the process and activity models, but can be regarded a complementary perspective.

Table 2.4 Comparison of process/activity models for analysing supplier involvement management

Authors	Activity/ process based	Level of analysis	Unit of analysis	Actor perspective	Contin-gency factors	Success/ enabling factors	Performance Measurement
Evans and Jukes (1999)	Process	Inter-company	Project	No	No	No	No
Dowlatshahi (1998)	Activity	Inter-company	Project	Explicit/Multiple Purchasing, R&D, Manufacturing, Supplier	No	No	No
Takeishi (2001)	Process/ Activity,	Intra and inter-company	Project	Explicit Multiple Buyer, Supplier Joint perspective	No	Yes	Yes, Single indicator
Wynstra (1998)	Activity, process	Intra-company	Stra-tegic, Project	Implicit Multiple,	Yes	Yes	No
Monczka (2000)	Process, activity	Intra-company	Strategic, Project	Implicit Multiple,	No	Partially, Success factors and barriers, conceptualised	No, (not in the model)
Håkansson (1987) and others	Activity, processes, resources and actors	Inter-company	Network, relation-ships	Not internal but actors in the network	Yes	No	No

2.8 What we know and do not know about supplier involvement

We ended section 2.3 by observing that the results of supplier involvement have been mixed. The literature review provided us with an insight into many different (managerial) aspects associated with supplier involvement. These different dimensions and adopted conceptual approaches have further helped us to understand what the crucial ingredients are to reap the benefits of supplier involvement. We have observed that during the past 15 years supplier involvement has been investigated in terms of the outsourcing of product development activities. Specifically, the extent of supplier involvement and the timing of supplier involvement have been commonly considered to be important underlying variables, characterising the nature of outsourcing. An increased scope of supplier responsibility in product development tasks and early involvement have been argued to provide explanations for observed performance differences.

Furthermore, a number of studies appear to suggest that effective supplier involvement takes place under the condition of a significant cooperative nature in the relationship between the buyer and supplier; these studies provided insights into the characteristics of this type of relationship such as trust, dependency and information sharing. Some authors have taken this notion a step further by opening up the cooperative relationship and identifying the different roles suppliers can fulfil during product development. This cluster of studies argued that their involvement requires a differentiated approach to manage the relationship or to co-ordinate the activities within a development project.

Within the purchasing literature, several studies have started to examine the activities and skills that enable an effective contribution to product development and to managing supplier involvement. This literature provides additional insights into those activities that might be crucial in creating the conditions to work with the right suppliers and achieve the results during the collaboration. In other words, there is more to managing supplier involvement than focusing on the direct collaboration in development projects. However, the 'purchasing perspective' can be criticised for its bias towards a specific actor (department), which may not provide a sufficiently complete picture of the influence and impact of other actors and the impact of other organisational processes and structures on the outcome of supplier involvement. Therefore, activity and process-based models are a first step in providing a more balanced view of effectively managing or indirectly supporting supplier involvement in product development. However, the majority of the currently identified models and studies focus primarily on the management of supplier involvement in development projects. They rarely measure the effects of the identified activities and conditions on short and long-term supplier involvement objectives. The Industrial Network Model, provides a perspective that suggests studying the relationships between multiple companies or at least 'one to many' company relationships. We argue that choosing a model that allows the study of supplier involvement from a combined internal and interorganisational view is not a wrong choice but is complementary to a network model and equally relevant.

When we analyse the clusters of literature, we encounter a common use of contingency theory in studying supplier involvement. The relationship between the company and environment has been investigated extensively in organisation studies. Several authors have investigated the ways in which the environment determines the optimal structure and strategy of a company. Contingency theory argues that no single organisational structure or process is effective in all circumstances. Studies by Burns and Stalker (1961), Woodward (1965) and Lawrence and Lorsch (1967) have contributed much to our knowledge that companies are adaptive organisations. In more focussed areas such as innovation management the need to investigate contingency factors also appears to be pressing. Damanpour (1996; 713) argues that, '*more elaborate and finer distinctions among types of organisations could help combine effects of multiple attributes and contingencies, perhaps leading to the development of more useful and realistic theories of structure-innovation relationships*'.

Studies on buyer-supplier relationships and specifically supplier involvement have adopted different contingency perspectives. Some studies have focused on those factors that determine the actual adoption of supplier involvement as a practice, i.e., providing more room for extensive and earlier involvement (Spina et al., 1999; Bidault et al., 1995; Kamath and Liker, 1994; Wasti and Nagamachi, 1997). These studies provide an insight into the extent to which supplier involvement actually takes place and what causes the differences between certain groups. Other studies examined the relationships between environmental/situational factors and the optimal structure or form of management supplier involvement in projects or the buyer-supplier relationship in general (Sobrero and Roberts, 2002; Wynstra and Ten Pierick, 2000; Bensaou and Venkatraman, 1995; Wasti and Liker, 1999). These studies suggest that the choice of the most effective type of communication mechanisms and behaviour when involving suppliers in product development are contingent upon the complexity and novelty of the final product or specific parts or the degree of externally generated technological change. Some have used a contingency perspective in determining those factors that drive effective purchasing involvement in product development. A variation on the use of the contingency perspective is the examination of those factors that affect the need for certain managerial activities to achieve effective purchasing and supplier involvement (Wynstra, 1998). One example included the fact that organisations that are highly dependent on suppliers need to pay more attention to those activities related to monitoring technological developments or motivating suppliers to develop specific products. The underlying assumption of the studies that investigate structure/management/performance relationships is that, during a certain period, organisations have some discretion to adapt their behaviour and structure to deal with the contingency, but that it cannot easily change the conditions itself. We can conclude that the adoption of a contingency view on managing supplier involvement provides a view that concurs with the diverse characteristics of the company and the circumstances in which it operates. However, a rather scattered set of possible contingency factors exists at different levels of analysis. We therefore detect a need to develop a more integral and coherent understanding of their relationship with the effective management of supplier involvement.

2.9 Conclusions

In this chapter we explored the literature on supplier involvement in product development. Our objectives were to examine the results and dimensions of effectively managing supplier involvement. A growing body of literature has started to study the supplier's contributions in the product development process. We found mixed evidence on their effect on lead-times, development cost reduction, product quality and cost improvements. This observation led us to review the literature regarding the notions and conceptual approaches that provide explanations for the mixed results. We identified five distinct clusters of studies based on key notions that have contributed to our understanding of the management of supplier involvement in product development.

An emergent view from the literature is that the realisation of these benefits depends on the characteristics of the (task) environment it finds itself in and the way in which the company interacts with suppliers and manages their involvement. It is here that a fragmented view exists of managing supplier involvement in product development. The literature has not provided us with sufficient insight into the managerial processes that are needed to organise and direct the involvement of suppliers on the 'short-term' within development projects and on the 'long-term' between consecutive development projects. The body of literature focusing on the contributions of various actors to the management of supplier involvement in product development has largely focused on the role of the purchasing department (e.g. buyer) and suppliers in this process. Such a focus alone provides a biased picture of managing supplier involvement in product development. We therefore established the need to develop and empirically test an integrated contingency-based framework for managing supplier involvement.

In Chapter 3, we will choose an existing analytical framework for analysing supplier involvement and its effects and discuss a number of adaptations in order to empirically study supplier involvement in companies. The literature review will serve as input for any required adaptations of the initial framework in the light of the research questions.

Chapter 3
Towards an analytical framework for managing supplier involvement in product development

3.1 Introduction

Our look at the current state of knowledge on supplier involvement in the previous two chapters led to the observation that inconclusive evidence is available about the positive effects of supplier involvement in product development performance. A number of studies have attempted to explain these mixed results by studying how companies 'cope with' supplier involvement. They point to the difficulties of managing the interdependencies between the actors, their activities and resources, as part of a network of relationships that affect each other (Håkansson, 1987; Axelsson and Easton, 1992; Håkansson and Snehota, 1995). The degree of discretion in truly managing supplier involvement is therefore considered to be limited by the existence of non-controllable actions, resources and the activity links of other companies.

Several studies searched for a more detailed explanation. They argued that differences in the internal and external contexts in which companies operate demand different forms of management practices associated with supplier involvement. Our preliminary conclusion was that a more integrated view on supplier involvement was needed in terms of managerial dimensions at different levels of analysis. Such a distinction is expected to better explain supplier involvement performance. We have chosen to use the 'purchasing involvement framework' (Wynstra, 1998), because of its initial recognition of different management dimensions and its incorporation of a contingent view on the need and form of these management activities.

In this chapter we present the purchasing involvement framework in greater detail. We then analyse the need for adaptations in the light of the specific research questions. Finally, we propose specific adaptations in preparation for the subsequent exploratory and explanatory empirical research phases.

3.2 Purchasing involvement framework structure and logic

In Chapter 2 we briefly introduced the Purchasing involvement framework along with other conceptual models as one of the few models that takes a broad perspective on the management of supplier involvement. It focuses on what the involvement of the purchasing function actually means in the product development process. Purchasing involvement is defined as, '*Contributing knowledge, taking part in managerial processes and participating in decisions with regard to product development, from a perspective of purchasing, i.e. striving towards optimal total product costs, well-balanced dependencies on suppliers, and an optimal technological match with suppliers' (Wynstra, 1998;*

65). The model identifies four basic management areas containing grouping in total 21 relevant tasks and activities that are needed for the effective and efficient involvement of the purchasing function in product development decisions. These activities have been linked to one or more underlying processes that strongly signal a 'meaningful' involvement of the purchasing function in product development.

Table 3.1 Purchasing involvement framework

Areas	Activities	Key processes*
Development Management	1. Determining which technologies to keep/develop in-house and which ones to outsource to suppliers	P,
	2. Formulating policies for the involvement of suppliers	C, T
	3. Formulating policies for purchasing related activities of internal departments	C, T
	4. Communicating policies and procedures internally and externally	I,
Supplier Interface Management	5. Monitoring supplier markets for technological developments	I
	6. Pre-selecting suppliers for product development collaboration	P
	7. Motivating suppliers to build up/maintain specific knowledge or develop certain products	M, C
	8. Exploiting the technological capabilities of suppliers	C,
	9. Evaluating suppliers' development performance	I
Project Management	*Planning:*	
	10. Determining specific Develop-or-Buy solutions	P,
	11. Selecting suppliers for involvement in the development project	P, M,C, T
	12. Determining the extent ('workload') of supplier involvement	P, C
	13. Determining the moment of supplier involvement	P, T
	Execution:	
	14. Co-ordinating development activities between suppliers and manufacturer	C, T, I
	15. Co-ordinating development activities between different first tier suppliers	C, T, I
	16. Co-ordinating development activities between first tier and second tier suppliers	C, T, I
	17. Ordering and chasing prototypes	C, T, I
Product Management	*Extending activities:*	
	18. Providing information on new products and technologies being developed or already available in supplier markets	I
	19. Suggesting alternative suppliers, products and technologies that can result in a higher quality of the final product	P, M, I
	Restrictive activities:	
	20. Evaluating product designs in terms of part availability, manufacturability, lead-time, quality, and costs	I
	21. Promoting standardisation and simplification of designs and parts	P, M, I

* P =prioritising, M = mobilising, C = Coordinating, T = timing I = informing,

Source: Wynstra et al., 1999

These processes were partially identified previously by Håkansson and Eriksson (1993) and further complemented by Wynstra with an extra process based on the case study data. Table 3.1 presents the management areas and lists the associated relevant activities and underlying processes. A number of factors have also been identified that are argued to strengthen the ability of companies to carry out these purchasing involvement activities. The model also takes into account that company-specific differences may increase the need and call for a specific form of specific activities for effective and efficient purchasing involvement to be realised. The framework was developed iteratively using two series of case studies at companies active in a variety of industries in the Netherlands and Sweden.

In the following sections we discuss these elements in the framework in greater detail before analysing and proposing adaptations. The examples provided in these sections are largely drawn from the case studies presented by Wynstra in his thesis. However, additional studies will be introduced to point out similar or contrasting findings.

3.2.1 Management areas and activities

In this section we discuss the various activities in order to define their core meaning and purpose. We will refer to the numbers of the individual activities as listed in Table 3.1.

Development Management activities

Development Management *(DM)* is concerned with the division of work between the manufacturer and its suppliers in developing and maintaining technological knowledge. This management area focuses on establishing the general policies and guidelines for supplier involvement in product development, and the technological areas in which to collaborate. The first activity (*activity 1 in the framework*) within DM concerns determining which technologies to keep/develop in-house and which ones to outsource to suppliers. The resulting 'in-outsourcing policy' indicates what the level of the manufacturer's involvement in technological development will be for different technologies. Obviously, there are more options than 'totally buy' or 'totally develop' a certain technology. One of the most difficult issues in the area of DM is to determine how much knowledge the manufacturer wants to keep in-house in order to be able to evaluate suppliers' technological competencies and their design suggestions. Clark and Fujimoto (1991) and Takeishi (2001) pointed out that manufacturers dependent on suppliers' engineering capabilities may lose some negotiation power. Furthermore, losing engineering expertise in core component areas can make a car manufacturer vulnerable in its technological capability in the long term. This activity therefore appears to be a critical continuous task, which actually encompasses other related, more continuous activities as well such as identifying the technologies relevant to the company, and analysing their relative 'value'. In several case studies Wynstra (1998) found that many companies had only determined their technology in-outsourcing policy to a very limited extent. This often leads to lengthy discussions at the beginning of (or even during) development projects, especially between purchasers and development engineers, as there are no clear guidelines on what should and should not be outsourced. By determining in advance which technologies to keep or develop in-house and which ones to leave to suppliers, and to what degree, a manufacturer may save time and effort at the start of a specific development project. It should be noted, however, that a clear in-outsourcing policy does not mean an inflexible policy. Apart from technologies that should always be bought and technologies that should always be developed internally, the policy could indicate certain areas where a decision should be primarily based on the specific context of a particular project.

Apart from developing an in-outsourcing policy for technologies, DM involves determining guidelines for supplier involvement and the purchasing-related activities of internal departments within product development (*activity 2 and 3*). These guidelines can indicate what the manufacturer expects from suppliers and vice versa, for example, in terms of communication, documentation and compensation. The guidelines may also indicate the responsibilities and activities of different internal departments regarding purchasing-related activities in product development, since the different activities need not be the domain of the purchasing department. Some activities can be carried out by people from the R&D department, depending on their expertise and experience.

Finally, without effectively communicating these guidelines to internal departments and to suppliers (*activity 4*), it may be difficult to create understanding and acceptance for the involvement of suppliers in product development. Guidelines can provide a constructive basis for discussing problems in the development process and serve as a reference in possible competence conflicts.

Supplier interface management activities

The area of Supplier Interface Management (SIM) deals with managing supplier relationships as a permanent and ongoing activity. It focuses on building an infrastructure or network of suppliers that can contribute to product development processes.

The first activity in this area relates to monitoring supplier markets with regard to technological developments, including the abilities of specific suppliers (*activity 5*). This type of market research targeted at technological aspects excludes research aiming to find a more competitive supplier for an existing standard product, and ad-hoc research triggered by a specific development project, such as a quick scan that seeks to identify an alternative supplier for a specific new component. It includes pro-active and continuous research with the aim of identifying suppliers or technologies that may be relevant for future product development.

The second activity in building and maintaining collaborative supplier relationships concerns pre-selecting collaboration partners (*activity 6*). This targeting of collaboration partners is not the same as deciding which suppliers are going to be involved in a specific development *project*. In the first place, the kind of collaboration that the manufacturer wants to maintain with these suppliers may not be related to a specific internal development project. A great deal of technological collaboration takes place outside the framework of a specific project, and has a more permanent character. Examples from the case studies by Wynstra (1998) are the different collaborations that Scania and DAF Trucks have with suppliers that are more focused on basic research than on the development of a specific truck or part model. In the second place, manufacturers may want to maintain relationships with a greater number of innovative suppliers for a specific product than they are going to involve in a development project. In that way, they do not become as dependent as they would if they always collaborated with one specific supplier. When targeting suppliers for technological collaboration, major aspects to consider are the supplier's technological and organisational capabilities (see Ardon and Van Weele, 1994;73-76). Apart from the capabilities of the supplier, it is important to consider the supplier's willingness or interest in collaboration. The potential for mobilising a supplier is one of the key issues in establishing an effective collaboration that is also efficient in terms of benefits versus resources invested.

This brings us to the third activity: motivating or getting suppliers interested in developing products (or parts of products) that the customer company needs (*activity 7*). To get a supplier interested primarily implies mobilising its resources. In listening and adapting to the manufacturer's needs and wants, the supplier has to consume some of its resources. One possibility for the manufacturer to mobilise the supplier's resources is to make the prospect attractive to the supplier, based on the business volume involved, its image, possible new product ideas, the access to production technologies, etc. (see Håkansson and Eriksson, 1993). Wynstra (1999) also found openness and swiftness in sharing information and technical feedback to be an important motivating factor. The importance of motivating a supplier to participate in technological collaboration is often underestimated because manufacturers are usually seen as being more powerful than suppliers, thus being able to 'demand' or even force their suppliers to collaborate (e.g. by threatening to withdraw business). This is not always the case. Some companies such as Sony and Alsthom have understood that marketing of the company's own resource and capability needs is a way to improve the access to, and willingness of, suppliers to cooperate. This is called 'reverse marketing' (Leenders and Blenkhorn, 1988).

Exploiting the technological competencies of suppliers is the fourth activity (*activity 8*). Instead of having the supplier develop products the manufacturer needs, 'exploiting' refers to letting the manufacturer adapt to the capabilities of its suppliers. The customer does not ask its suppliers to develop certain products which it needs for its new end products, but it closely watches and analyses the capabilities of suppliers, and adapts to them by building a new product around the part or material developed by a supplier. This way of exploiting technological capabilities by a 'reversing of roles' can be especially effective when a customer is faced with large, powerful or very innovative suppliers.

The final SIM activity concerns evaluating supplier performance with regard to product development (*activity 9*). These evaluations can then be used for maintaining an up-to-database of suppliers (for different products and technologies) that can perform development activities for the manufacturer. This makes the selection of suppliers for involvement in a specific project more efficient by reducing the need to search for and rate suppliers at that specific moment. Periodical assessments may take place mainly at the level of the development *process* at the supplier, for example in terms of adherence to deadlines, reliability and quality in communication and documentation. To some extent, the assessment can also take place at a *product* level, for example by reviewing the quality and cost of previously developed parts compared to the original objectives. The assessments may involve a combination of objective methods such as a vendor rating on quantitatively measurable aspects and more subjective methods such as personal assessments by engineers and purchasers (Van Weele, 1994). However, Wynstra notes that assessment methods specifically targeted at product development performance only seem to have been developed recently.

Project Management activities

The area of Project Management (PJM) is primarily concerned with managing the involvement of suppliers in specific development projects. Within the area of project management, two specific sub-areas can be distinguished: *project planning* and *project execution*.

Planning activities are performed at the start of a development project, while execution activities are performed during a project. The first project planning activity regards project-specific develop-or-buy decisions (*activity 10*). These decisions have already been discussed under the heading of development management as a long-term activity, but also need to be considered in the context of specific projects. For example, Wynstra (1999) found that one of the case study companies, Philips Medical Systems, had a general technology in-outsourcing policy, but this did not always automatically imply which decisions should be taken at the project level. This occurred, for instance, when the component involved incorporated a totally new technology not yet considered or when the project needed to meet a tough deadline, meaning that the manufacturer could not undertake all development work that it usually undertook.

The second activity, selecting suppliers for involvement in the development project, is similar to the Supplier Interface Management activity of pre-selecting or targeting suppliers for collaborative product development, but now in the context of a specific project (*activity 11)*. Again, the choice has to be based on the supplier's capabilities and willingness to collaborate. However, the selection at project level also requires timing. When a supplier has a lot of other things going on, it may be very difficult to involve it in (substantial) collaboration, because the resources that companies control are generally limited. On the other hand, if the manufacturer manages to pick the right moment, a supplier may be especially keen on collaborating. The issue of which supplier to involve in a project becomes especially relevant when the manufacturer has several suppliers for a specific product. In the automotive industry in particular, it seems to be common practice to involve two or three suppliers in a development project in the form of a 'design contest', where the losing supplier may become a secondary supplier for that model (Dyer and Ouchi, 1993;57). However, this practice takes resources, which may make it prohibitively inefficient. Manufacturers therefore have to balance the costs and benefits of involving more than one supplier (Bonaccorsi and Lipparini, 1994).

The third activity, determining the extent of supplier involvement, is closely related to the first two activities in project planning (*activity 12*). It is related to decisions on develop-or-buy issues; these decisions will not only involve 'totally buy' or 'totally develop' options, but also intermediate solutions, and will thus give a general indication of the required extent of supplier involvement. It is also closely related to the process of selecting the supplier; the kind of workload that the manufacturer wants to give to a supplier will influence the criteria used in supplier selection. Conversely, the kind of supplier that is available may limit the workload a manufacturer can give to the supplier.

The fourth and final activity in *project planning* involves determining the moment of supplier involvement (*activity 13*). Determining this moment, or more precisely differentiating between different moments for different suppliers, contributes to using the manufacturer's resources for managing this supplier involvement as efficiently as possible and to supporting the progress of the development process.

While the *project planning* activities are primarily carried out during the initial phase of a development project, or even prior to that, *project execution* involves activities during the project. The first *project execution* activity concerns the co-ordination of the development activities of suppliers with those of internal departments of the manufacturer (*activity 14*). Wynstra found that the need for co-ordination is not always very strong. He observed that, in the collaboration between Ericsson Radio and Ericsson Components, there was no real 'joint' development taking place. In contrast, in the collaboration between DAF Trucks and Bosch, more co-ordination of the development activities took place between both companies. This is because DAF itself also spends a lot of effort on R&D regarding injection systems and their interaction with other parts of the truck engine.

The second activity concerns horizontally co-ordinating the development activities of different suppliers (*activity 15*). Horizontal co-ordination, for example between the development activities of a mechanical parts supplier and an electronics supplier, is quite common; almost every product contains parts supplied by more than one supplier, and innovations in the product often affect more than one part. This need may depend on the degree of modularity or the simplicity of the interfaces between two parts, which may reduce the need for co-ordination regarding technical development aspects between different horizontal suppliers.

The third activity concerns vertically co-ordinating development activities of different tiers of suppliers (*activity 16*), as practised by manufacturers in the electronics and auto industries (Kamath and Liker, 1994; Hines, 1994). In the case of a plastic components producer Perstorp, Wynstra found that its customers (automobile manufacturers) often have direct technological collaborations with second tier suppliers of raw material such as granulates and resins about the temperature resistance and colours. This occurs in parallel with the collaboration these customers have with Perstorp about the actual design of the component. It is important to observe that it is not always and exclusively the manufacturer that carries out this horizontal and vertical co-ordination of development activities; suppliers may carry out this co-ordination (partly) by themselves too. Horizontally, suppliers may co-ordinate their efforts directly with each other, with only limited ('arms length') involvement of the manufacturer. This happens particularly when the suppliers know each other well, for example through operating in the same teams in relation to a manufacturer. This can happen in vertical co-ordination too, when the manufacturer lets the first tier supplier co-ordinate its development activities with those of second tier suppliers (cf. Nishiguchi, 1987; Hines, 1994). When a manufacturer chooses to deal directly with lower tier suppliers, it is usually because it regards a product technologically to be crucial or financially speaking, or because suppliers do not have the skills to undertake this co-ordination.

The final activity concerns co-ordinating prototyping and production start-up (*activity 17*). The co-ordination of the design and delivery of prototypes is very important for a successful development project, and a good performance of suppliers in this context is often crucial (Wheelwright and Clark, 1992; Kamath and Liker, 1994).

Product Management activities

Product Management (PDM) focuses on defining the actual product specifications within a development project. It encompasses decisions on how to structure the design, what technical norms and standards to use, what materials to consider, etc. With regard to actually assisting in the development of the new product, i.e. directly contributing to the specifications of the product, Wynstra categorised activities into 'extending' and 'restrictive' contributions to the product development process. Restrictive activities are aimed at limiting the number of alternative specifications, while extending activities are aimed at increasing the number of alternatives (Erens and Van Stekelenborg, 1993; see also Dowlatshahi, 1992). In the first place, PDM involves *providing information on new products and technologies that are available or being developed in the supplier market* (*activity 18*). This is an activity that is especially relevant in the first phases of a development project. Somewhat later during the project, after the first options have been reviewed, PDM involves suggesting alternative suppliers, products and technologies in order to achieve a higher product quality (*activity 19*). Both these 'extending' activities are closely connected to the activities in the area of Supplier Interface Management, especially the monitoring of supplier markets. *Suggesting alternatives* is closely related to the third activity: evaluating product designs in terms of availability, manufacturability, lead-time, quality and costs (*activity 20*). This involves informing internal departments about various suppliers' abilities or inabilities to meet specifications, giving information about costs, performance, part availability, quality and reliability of particular components (Burt and Soukup, 1985). Finally, PDM includes finding other parts that have more common specifications, in order to gain efficiency and purchasing leverage (*activity 21*). *Part standardisation and simplification* can reduce costs, the number of suppliers needed, and the time and cost of designing and producing the final product (Wheelwright and Clark, 1992; Kamath and Liker, 1994).

The identification of four management areas with their different activities shows us that the involvement of purchasing is not limited to managing supplier involvement in single development projects. Although these management areas are presented as if they are separate from each another, this is not really the case. The activities are connected and together they support each other in the same area.

3.2.2 Key processes underlying purchasing involvement

These activities are considered to be relevant for inclusion in the framework as a result of an evaluation of the activities in terms of their contribution to one or more key processes underlying purchasing involvement. These processes are *prioritising, mobilising, co-ordinating, timing* and *informing*.

Prioritising refers to the choices the manufacturer has to make about how and where to invest his resources. This not only involves the choice of actual collaboration partners, but also the choice for a specific form and intensity of supplier involvement (Håkansson and

Ericsson, 1993). Companies need to set priorities regarding the technical areas or specific suppliers they want to work with. Without prioritising, supplier involvement may cost more time and effort than it saves. We can observe that the activities 1,6,10 to 13,19 and 21 (in Table 3.1) perform a prioritising function. *Mobilising* involves encouraging or motivating suppliers to start working on a particular development. Without mobilisation, suppliers may not be interested and willing to make the necessary commitments and efforts. Specifically, the activities 'motivating suppliers...' (activity 7), selecting suppliers..' (activity 11), 'suggesting alternatives...' (activity 19) and 'promoting standardisation and simplification...' (activity 21) reflect the mobilising character as they concern trying to convince or motivate various functions (such as R&D or production) to choose certain options (Table 3.1). *Coordinating* involves the adjustment and adaptation of development activities and resources between suppliers and the manufacturer. Without co-ordination, joint development will result in ill-fitting components, double work, incompatible technical solutions, etc. This need for co-ordination grows with the increasing specialisation and fragmentation of development activities. Coordination is an underlying key process of activities 2,3,7,8,11,12 and 14 to 17 (Table 3.1). *Timing* is a special kind of co-ordination, which involves the co-ordination and adaptation of development activities and resources in time. Without timing, product development will suffer from (unexpected) bottlenecks, such as unnecessary delays and missed deadlines. Timing is an underlying key process of activities 2,3,8,11 and 13 to 17 (Table 3.1). The fifth and last process *'informing'* has been identified to underline the difference between purchasing involvement and managing the actual supplier involvement in a development project. The key process 'informing' refers to both acquiring and disseminating information before or in parallel with the actual involvement of a supplier. For example, carrying out market research, evaluating different alternative component designs in terms of availability and costs. Informing is an underlying key process of activities 4,5,9,14-17 and 18 to 21 (Table 3.1).

3.2.3 Driving and enabling factors for purchasing involvement activities

Besides the identification of several activities constituting purchasing involvement in product development, it is argued that not all of these activities may be equally necessary or important in all situations. Variations between companies in terms of the actual extent and form of purchasing involvement in product development may be explained by two groups of factors. The first group of factors refers to specific environmental characteristics that condition the need for, and determine the specific form of, executing the purchasing involvement activities. In other words, the model adopts a contingent view on purchasing involvement, in which some companies will have a greater need to pay attention to activities in certain management areas. The following four factors driving the need for purchasing involvement have been identified (Wynstra, 1998; 131):

1. company size;
2. production type or technology;
3. the overall dependence/reliance on suppliers;
4. the importance of product development.

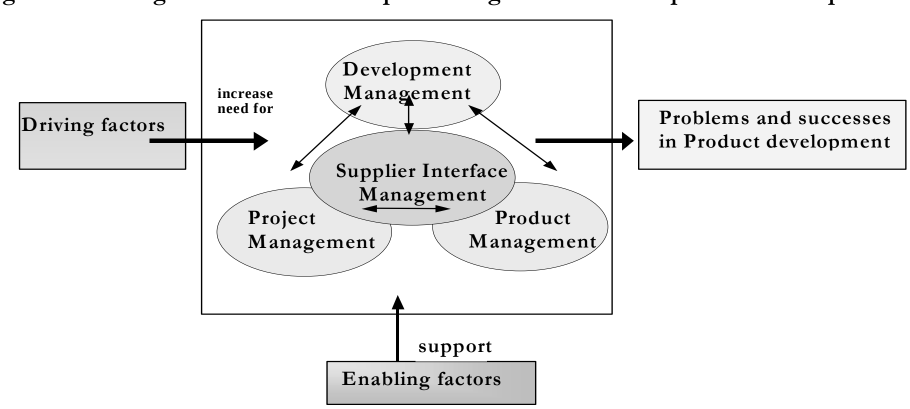
These are primarily company-related characteristics that are fixed, at least on the short-term. Wynstra (1998, 131) states, '...the four factors have been selected primarily on the basis of notions of the relation between purchasing and product development and are in fact hypothetical driving factors'. However, there may be additional important factors at different levels of analysis that do affect the need and form of some of the activities in the framework. We will come back to this observation in the next section.

The second group of factors refers to those conditions that affect the ability of a company to make use of purchasing involvement. Three main enablers have been identified:

1. the presence of an internal organisation that is able to support the required communication and co-ordination in product development;
2. the quality of exchange and recording of information between different actors relevant to the product development process and its management, possibly supported by information technology; and
3. the quality of human resources in terms of personnel, with the right education, skills and experience.

It is argued that the total model can be used to explain problems and successes in product development by investigating the pattern of purchasing involvement activities. This purchasing involvement activity pattern, in turn, is explained by the driving and enabling factors in that specific situation. Their interrelationships are shown in Figure 3.1. If in developing new products, a company is experiencing problems related to purchasing and supplier aspects (such as delays due to suppliers not delivering prototypes on time, or problems in meeting cost-targets due to the use of expensive customised components) the explanation may be found in terms of those driving and enabling factors. The problems are a sign that there is a gap between the actual and the desirable pattern of purchasing involvement; either the company is not aware that it needs to have a certain degree and form of purchasing involvement or it is unable to achieve it. Insights regarding the driving and enabling factors provide some first indications of when to carry out specific activities from the framework, and the requirements for performing them.

Figure 3.1 Integrated framework for purchasing involvement in product development



We now describe in more detail what each factor is comprised of, and what its hypothesised relationship is with the purchasing involvement activities.

Driving factors and hypothesised relationships with purchasing involvement activities

The *company size*, is argued to increase the need for 'Development Management' activities. It is measured by the number of employees and is an indicator of overall organisational complexity. Wynstra (2000) found that the larger companies often had more extensive programmes on purchasing and supplier involvement than the smaller ones. The need for more guidelines in larger companies stems from the fact that they are more complex organisations with larger number of employees and departments. Such complexity will render it inefficient if all people simply agree on doing their tasks verbally. If an organisation is small, the few people concerned may simply agree on doing things a certain way, without (formally) labelling and communicating it as guidelines or policies (Wynstra, 1999). A certain degree of formalisation (e.g. using guidelines) makes larger organisations more efficient in carrying out certain tasks (Mintzberg, 1979). These guidelines can still provide enough discretion for departments to perform certain tasks according their professional insight. Furthermore, Spina et al. (2002) found that larger companies tend to co-design with their suppliers more than smaller companies. They argued that maybe only larger companies enjoy the scale to make it worthwhile for suppliers to enter a co-design relationship. It is therefore more important to develop and communicate guidelines for supplier involvement.

Production type has been hypothesised as a second possible driving factor. For example, companies from large series assembly industries may have a greater need of Project and Product Management activities. When performing assembly operations, it is likely that many different parts with a relatively high degree of complexity (e.g. sub-assemblies) will be involved. This emphasises the importance of co-ordinating development activities between different suppliers. Therefore, the Production type is viewed as a factor that increases the need for 'Project Management' activities.

The third possible driving factor regards the overall *dependence/reliance on suppliers*. The more dependent a company is on suppliers for producing its final product, the more likely it is to be dependent on suppliers for developing that product. One way to measure this dependence is by taking the purchasing share in turnover (purchasing ratio). In the explorative case studies, the success of development projects at companies with high purchasing ratios seemed to be much more dependent on supplier efforts than in those cases with lower purchasing ratios. This has been confirmed by Bidault and Butler (1998) and by Spina et al. (2002) who found in their surveys that companies with a high purchasing ratio (> 70%) do indeed adopt earlier and more intensive supplier involvement. This ratio is argued to influence the need for the more permanent and long-term oriented activities to develop a capable supply base to be involved in future development projects (e.g. monitoring supplier markets, exploiting suppliers' technical capabilities and supplier performance rating).

The fourth and final driving factor regards the *importance of product development*, reflected in the relative level of R&D expenditure. It is hypothesised that companies with a higher R&D

intensity need to pay more attention to their Development Management activities. Although there is no one-to-one relationship between R&D expenditure and product development (some expenses may be related to basic research or process innovation), it is reasonable to assume that the higher the expenses on R&D, the more likely product development is to take place. Spina and Zotteri (1999) and Spina et al. (2002) found some preliminary evidence that the more companies invest in R&D, the more they tend to involve suppliers in co-design projects. Consequently, all things being equal, more product development means a greater need for purchasing involvement. For example, there is likely to be a higher need to carefully determine which technologies to keep in-house and which ones to outsource.

Enabling factors and hypothesised relationships with purchasing involvement activities

The first enabling factor involves an internal organisation that supports the effective and efficient purchasing involvement in product development. Wynstra analyses the internal organisation in terms of the functional structure of the purchasing department and the project organisation of the product development team. Regarding the organisation of the *purchasing department*, two aspects are of importance. The first aspect is the *degree and principle of specialisation* within the department. The degree of specialisation to some extent determines the knowledge a purchaser can achieve about suppliers and specific products. When a purchaser is responsible for a broad range of products and suppliers, it is difficult to know every detail of individual suppliers and products. The principle of specialisation is also important. While purchasers may be specialised in terms of suppliers that produce different products, engineers may be specialised on the basis of technologies (plastics, ceramics, etc.). This method of specialisation can render the communication between the two departments more complex than when both purchasers and engineers are specialised according to the same dimension (Wynstra 2000). The second important aspect is the *horizontal complexity* of the purchasing department. Horizontal complexity refers to the number of different units or groups with specific tasks within a department (Daft, 1986; 18). In the explorative cases, it seemed that when a purchasing department consists of a unit performing the operational purchasing tasks and a unit performing the initial purchasing tasks, this may increase the overall ability of that department to perform those initial, product development-related tasks. On the other hand, a very high degree of complexity may make it more difficult to co-ordinate various activities within the purchasing department itself.

Regarding the organisation of the *product development team*, Wynstra et al.(2000) suggest three important aspects: structure, composition and location. The teams can be structured in different ways. At the one extreme there are team structures that consist of people that are still very closely connected (in terms of task performance control and career paths) to the functional organisation of their company, and where no strong project manager role exists. At the other extreme, there are autonomous team structures, where individuals from different functional areas are fully dedicated to the project team and where the project leader has a very strong position, for example, in task performance evaluation (Wheelwright and Clark, 1992). Apart from the structure of the development team, the *composition* of the team is also a major decision variable. The participation of the purchasing function may benefit the performance of the activities from the framework. Most importantly, participation means that purchasing representatives are likely to be better informed about the project, which enables them to better 'tailor' some of their activities to the needs of the project. The third aspect of the organisation of product development teams regards their *physical location*. For the complex communication involved in product development to evolve rapidly and effectively, close physical location of development team members is often argued to be of great importance (Wheelwright and Clark, 1992; 20). The formal participation of purchasing in a 'strong' development team can lead to a more substantial and structured consideration of the various purchasing related activities in the product development project.

The second enabling factor regarding purchasing involvement in product development is related to the *exchange and recording of information*. Product development can be seen as a problem solving process that requires information processing (Bensaou and Venkatraman, 1995; Brown and Eisenhardt, 1995; Daft and Lengel, 1984). A lot of activities require information to reduce uncertainty in a project and to make trade-offs in the design process. It is argued that when information is readily available and accessible to those who need it (e.g. supplier, purchaser and engineer), this may facilitate their mutual communication and the performance of other tasks. For example, the presence of a shared Product Data Management system providing details on the product structure and components which is coupled to CAD/CAM systems. Wynstra (2000) suggested different tools that could provide information to facilitate decision making regarding activities such as selecting suppliers and suggesting alternative technologies and standardising components. These tools include a preferred supplier list with information concerning their specific technical capabilities and a standard component database with indications on availability and costs to support certain engineering decisions (Burt and Soukup, 1985; Handfield et al. 1999). The update of this information appeared to be a crucial aspect of the degree of support for involving purchasing.

The third enabling factor is the quality of *human resources*. As we have observed in Chapter 2, previous research has actually given some attention to the role of human resources as an enabling factor for purchasing involvement. In doing so, it has focused primarily on the attributes of buying personnel, assuming that they make a bigger difference than the personal attributes of development engineers or other members of the organisation. Several attributes are usually distinguished (Anklesaria and Burt, 1987; Guy and Dale, 1993; Atuahene-Gima, 1995; Dobler and Burt, 1996): (1) kind of previous experience, (2) kind and level of training/education, (3) degree of technical expertise (4) degree of pro-activeness and (5) capabilities as perceived by others (credibility).

Previous experience that purchasers have had in other functions within the company, primarily the technical functions such as engineering, may enhance not only their technical expertise but also their understanding of how they can contribute to the product development process. The *kind and level of education* purchasers have is the second aspect that may affect their involvement in product development. Research has found that purchasing managers with a university education are more likely to be involved in the product development process than those without. These first two aspects can be seen to contribute to the third aspect: *degree of technical expertise*. Technical expertise enables the purchaser to 'speak the engineer's language'. The fourth aspect concerns the *degree of pro-activeness* of buyers. Pro-activeness refers to the willingness of purchasers to participate in activities related to product development and demonstrated by action. Purchasers who are content to focus on routine tasks such as filling out ordering forms will be reluctant to participate in more uncertain processes such as product development. The final aspect of human resources concerns the overall capabilities, as others perceive them. No matter how technically skilled and pro-active purchasers are, if their counterparts in the product development process do not perceive purchasers as being capable of adding value to the process, the involvement of purchasers will be not be very effective.

These three factors or elements - *organisation*, *information* and *human resources* - affect the company's ability to perform the different activities or tasks, and to perform them in an efficient and effective way. 'Efficient' means that the efforts spent on carrying out the activities are optimised, and 'effective' means that the activities result in the desired outcome.

We stated earlier in this chapter that the 'purchasing involvement framework' serves as an initial analytical framework for examining the critical activities and conditions resulting in effective supplier involvement. This framework addresses an important shortcoming as pointed out by Takeishi (2001) regarding the lack of research on the internal organisation and management of supplier involvement. It therefore provides a useful starting point for investigating managerial and organisational aspects to achieve effective supplier involvement. However, we need to carefully analyse whether it is completely suitable for this purpose and, if it is, what changes it needs beforehand. In chapter one we noted that the purchasing involvement framework is rather complex. The complexity is demonstrated by the list of 22 activities (see Table 3.1) and their connections to five underlying processes. We still do not know whether this set of activities is complete. The processes may be a conceptual yardstick for indicating the function of carrying out different activities and presenting arguments for inclusion in the framework. However, determining the inclusion or omission of activities may require (additional) empirical observations and analysis of these activities in relation to the performance of supplier involvement and of their connection to other activities. Moreover, the enabling factors may not sufficiently explain the conditions required for effectively organising supplier involvement. For example, the enabling factors suggested by Wynstra may be too biased towards the purchasing organisation while practically neglecting the organisation of the R&D department. While the framework does hypothesise broad contingent relationships between the certain conditions and the need for certain management areas, it does not yet demonstrate sufficiently which activities are most critical in effectively involving suppliers in product development. These observations raise some questions as to the framework's suitability for answering the research questions.

In the next section, we propose a number of adaptations beforehand to the 'Purchasing involvement framework' that will provide the necessary starting points for the empirical research phase. We argue that the framework needs five main adaptations, consisting of re-labelling, adding variables, and conceptually distinguishing different levels of analysis. Our first adaptation consists of introducing different variables to measure the effects of supplier involvement. We then add driving factors to those already identified in the 'Purchasing involvement framework'. These factors have been found in the literature on supplier involvement in product development and in the literature on product development and innovation management. The driving factors are grouped into three different levels of analysis: business unit, project and relationship. Similarly, in addition to the enabling factors identified in the internal organisation, we add enablers that can be identified in the external supplier organisation and in the buyer-supplier relationship. We then re-label the name of the framework from 'Purchasing involvement' to 'Integrated Product Development and Sourcing'. Finally, the framework is related to the 'Open Systems Model' (Katz and Hahn, 1980; Harrison, 1987) describing the phenomenon of supplier involvement from a managerial perspective as being dependent on its environment and using resources from it.

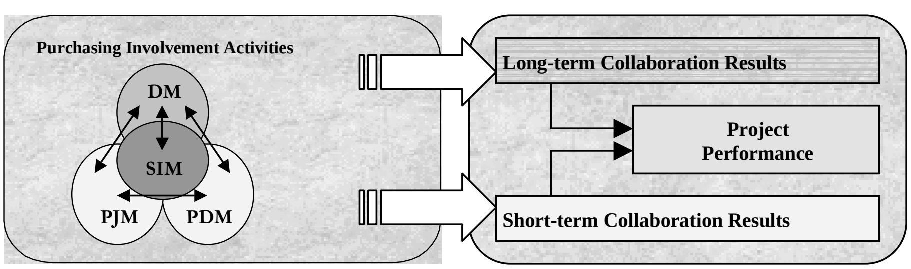
3.3 Adaptations

3.3.1 Identifying the results of supplier involvement in product development

Our first research question calls for a more comprehensive understanding of the performance of supplier involvement. We therefore identify different objectives, in theory, and incorporate them as performance dimensions into the model to allow us to measure the results of supplier involvement empirically. Until now the 'Purchasing involvement framework' has not explicitly incorporated performance dimensions. It went as far as referring to the occurrence of certain problems and successes related to supplier involvement. This demarcation was understandable given the nature of the initial objective in the study by Wynstra (1999) to define what constitutes purchasing involvement. However, we cannot just investigate the contributions to the five underlying key processes of purchasing involvement, as we are unable determine their impact on performance measures that are more direct and relevant to practice.

Our first proposed adaptation is to incorporate the previously identified short and long-term collaboration results into the framework (see Figure 3.2).

Figure 3.2 Identifying the 'results' of supplier involvement



The first group, which we refer to as '*short term collaboration results,* measures supplier performance in a development project in terms of typical project performance indicators such as: (1) part cost, (2) part performance (quality), (3) part development costs and (4) part development time. These short-term collaboration results in turn are argued to contribute to the overall project performance in terms of the same indicators but then at the project level. As discussed in chapter two, the first set of two indicators reflects a measure of effectiveness of the supplier involvement effort, while the third and fourth indicators represent a measure of efficiency. Effectiveness is the degree to which output objectives have been achieved in the context of a development project. Efficiency refers to the required input needed to achieve objectives reflected by the development time and development costs used. We must, however, take into account that the targets of certain projects may receive different priorities from top management (Tatikonda and Rosenthal, 2000), meaning that one performance indicator, such as time-to-market, may be relatively more important to the company than another, such as product cost. Furthermore, we need to be aware of the alternative possible explanations for a performance deviation. A deviation can be caused by other events internal or external to the development project, such as an unexpected product introduction by a competitor questioning the value of previously set objectives.

The second group of results of supplier involvement have a more long-term and/or strategic character which we call '*long-term collaboration results'*. We identify four benefits that a company may want to achieve. As became clear in the previous chapter, companies involving suppliers for the first time may not be able reap the benefits immediately, but the experience in one project may provide learning opportunities, resulting in a faster and less resource-consuming collaboration next time. Ragatz (1997) reported that companies felt that future collaborations in product development can be carried out more effectively and efficiently due to soft benefits resulting from collaboration in a specific project. Sobrero and Roberts (2001) argued that development projects are faced with a trade-off between achieving targets set for specific parts and long-term learning. We need to further investigate whether this trade-off is really there. In addition, Bruce et al. (1995) argued that the experience gained in managing collaborations could be an invaluable asset for future collaborative endeavours. Simonin (1997; 1156) states that,

> '*As companies develop collaborative know-how, future collaborations should result in superior tangible and intangible benefits. Increased collaborative know-how, in terms of searching for, negotiating, managing, monitoring, and terminating collaborative arrangements can provoke more informed decisions about further collaborations and more realistic and achievable objective settings for collaborations.*'

Furthermore, the collaboration in one project may not have increased the performance of a project in terms of the four indicators, but was successful anyway because of 'improved access to a critical technology' (Ragatz, 1997). This access is important if it was not possible to develop the technology on time internally. A specific prioritisation of resource allocation or a lack of internal capabilities makes the access to external sources of technology important.

A third benefit that has been mentioned is the alignment of technology and product roadmaps (Monczka et al. 2000; Handfield et al. 1999). This means that the buyer and supplier achieve a matched planning of expected technological opportunities provided by the supplier in relation to future product/market opportunities and internal technology development plans. The fourth benefit that supplier involvement could have is its positive effect on the innovative capability of the company. Suppliers' new designs and innovations may be critical in helping the buyer to differentiate its product in the market place (Dyer, 2000).

We have not incorporated any changes related to the four management areas; further empirical research should explore whether they are complete and whether the actual activity pattern can help to explain the observed collaboration results. We need to develop further insight into whether the purchasing involvement activities provide the complete and correct level of detail for managing supplier involvement.

3.3.2 Introducing additional driving conditions

In Chapter 2, we observed that several studies on supplier involvement have used a contingency view on managing supplier involvement. Several conditions have been identified that act as contingencies to which a company needs to respond in terms of differentiated behaviour or organisational structures. We therefore argued that we need to further investigate the role of antecedent conditions that influence the way supplier involvement should be effectively and efficiently managed. The contingency perspective is based on the assumption that, within a period, organisations have some discretion to implement behaviour to deal with the contingency, but that they cannot easily change the conditions themselves. Lakemond (2001) suggest product-related factors and supplier-related factors as primary differentiator categories to determine the appropriate type of co-ordination in a development project. We use a slightly different categorisation in order to also consider those factors that determine the need for non-project-related management activities (such as DM and SIM).

We argue that driving factors have been largely found at the business unit/company level, the project level and the buyer-supplier relationship levels of analysis. We propose to distinguish a group of '*business unit driving factors*'. Authors such as Spina (1999), Wynstra (1998) and Eisenhardt and Tabrizi (1995) investigated particular market and organisational characteristics that represent equal contingency conditions for a whole company or a business unit. Although higher levels of analysis exist, such as the network and community level, we argue that little research has so far connected the characteristics of networks and communities to the management of supplier involvement in a company. Since Wynstra (2000) only focused on the driving factors at company or business unit level, while other relevant characteristics have been found in the literature, we decided to add other driving factors to our framework.

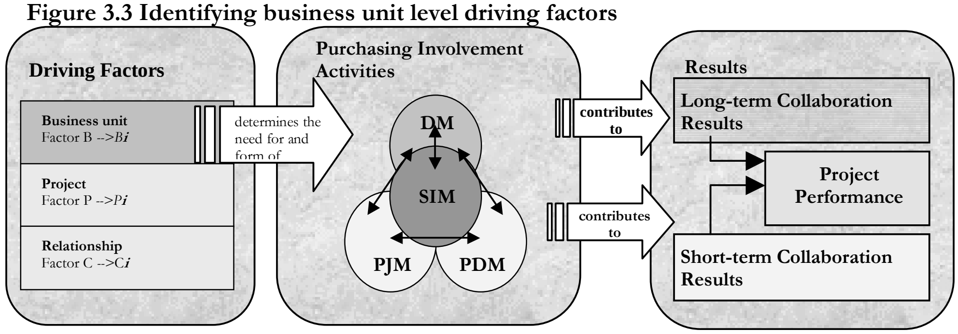
The second group contains a number of '*project driving factors*'. A number of studies in product development literature and on supplier involvement used development projects as their level of analysis. Differences between projects on certain dimensions were argued to affect the need for a differentiated approach to those management activities and organisational arrangements that pertain to a whole development project. In Lakemond's categorisation these dimensions pertain to characteristics of the product to be developed. The final group contains '*relationship driving factors*'. We found various studies on supplier involvement studying the relationship or a specific episode of collaboration regarding the development of a part. These studies investigated contextual factors that are argued to trigger the use of a differentiated form of relevant managerial decisions and activities related to a specific collaboration.

We will now examine the factors that have been proposed in literature in more detail at each level, and determine their theoretical relationship with the need for specific managerial activities of the framework.

Business unit driving factors

At the business unit level, we can identify structural characteristics of the company or business unit and characteristics of the broad environment in which the company or business unit operates[5]. The four driving factors already identified in the 'Purchasing involvement framework' can be regarded as structural characteristics.

Figure 3.3 Identifying business unit level driving factors



In addition to these factors, external environmental characteristics, such as the uncertainty in the environments surrounding companies, also determine the need for specific innovation practices and the adoption of organisational structuring mechanisms (Souder, 1988). We argue that the *degrees of market and technological uncertainty* that a specific business unit is facing may be two additional factors that drive the need for more attention and resources to carry out Development Management and Supplier Interface Management activities. In the study by Eisenhardt and Tabrizi (1995) the role of market and technological uncertainty can be viewed as a driving factor for differentiated supplier involvement. They found that companies operating in turbulent environments and involving suppliers earlier in development projects may be less effective in decreasing the time-to-market than companies active in environments with more stable technology and demands. Market uncertainty was defined as the degree of maturity and stability of markets. Technological uncertainty was defined as the degree to which

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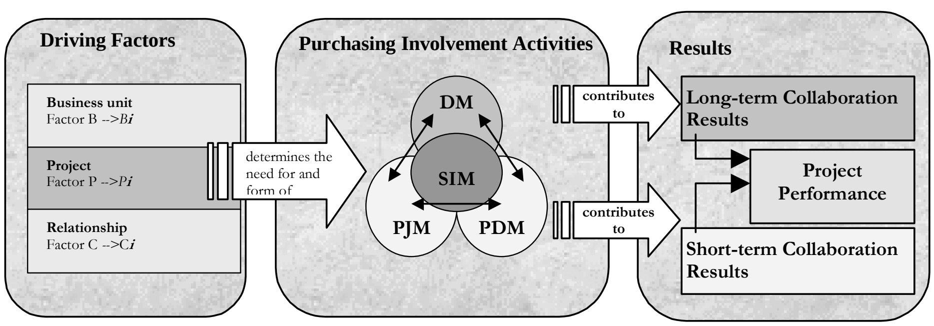
[5] The company level is not always the relevant level of analysis given the large internal diversity of (unrelated) product/market combinations for which some of the characteristics may not apply. We therefore choose to look at the business unit level, unless the company does not have business units or they are homogeneous regarding the external environmental characteristics.

companies are insulated from changing technologies. Where technologies and market demands are highly volatile, this increases the importance of carefully considering which technologies to source externally and which ones to develop internally; a wrong decision can result in a situation where it is impossible to catch up with the competitors. Certainly, in those industries where companies are battling to turn their technologies into their standards, intensively monitoring which technologies become available when may become an ever more pressing problem.

Project driving factors

In addition to the driving factors that affect those activities at business unit level, we have also come across different contingencies that pertain to specific development projects. At the project level, we suggest 'project complexity' and 'degree of project innovation' as important driving factors. In the literature review, we found several authors arguing that the 'complexity of a development project', the 'technological uncertainty surrounding the development activities' and the 'degree of project innovation' affect the way in which new product development is organised and managed (Tatikonda and Rosenthal, 2001; Tidd, 2001; Swink, 1999). Their main argument is that development tasks must be structured in a different way, and that the required timing and availability of relevant information must be supported with the right communication mechanisms in order to reduce the uncertainty and to manage the dependencies. These proposed factors also provide clues regarding the need for specific supplier involvement management and purchasing involvement activities.

Figure 3.4 Identifying project level driving factors



Project complexity is often reflected in the degree of interdependence of development tasks. The higher the interdependence of tasks (Thompson, 1967), meaning the output of one task is used as the input of the other and vice versa, the more co-ordination between these activities is necessary. Furthermore, this complexity may also be reflected in the size of the project. Swink (1999) points to the higher co-ordination complexity when the number of organisational departments and technical specialists present on the project team increases. Such specialists can be suppliers as well. Therefore, the larger the project the greater the difficulties associated with the co-ordination, with the evaluation of design trade-offs and with the simplification of design steps.

The *degree of project innovation* constitutes another driving factor increasing the need for project and product management activities. New products differ substantially in the degree to which they employ new technologies (Cochran et al., 1978; Clark et al., 1988). The degree of project innovation has been discussed in literature in terms of the extent to which new product and process technologies are adopted (Tatikonda and Rosenthal, 2000) or developed, or the degree to which linkages between components are rearranged whilst using existing technologies (Henderson and Clark, 1990). The implications of developing new product and process technologies in a project is the increase in technological uncertainty that results from a lack of knowledge about technological solutions (Utterback, 1971; Moenaert and Souder, 1990).

In the supplier involvement literature, differences in the innovative character of the final product have been argued to require different moments of involving various suppliers and co-ordination mechanisms for collaborating with suppliers (Ragatz et al. (2002), Lakemond (2001) Maffin and Braiden (2001), Swink, 1999). Maffin and Braiden (2001) argued that projects with higher levels of process innovation and a more pronounced supplier collaboration requirement have a greater need for integration between the different functions and suppliers. Lakemond (2001) proposes different organisational arrangements that provide various degrees of co-ordination power, which may be more effective in highly innovative development projects or characterised by high task interdependence. Furthermore, Swink (1999) provides an interesting dilemma which points out that projects employing new product and process technologies require conscious consideration of when to involve suppliers. She argued that highly innovative development projects require more experimentation and analysis to ensure the compatibility of design specifications to process capabilities. This may point to the need for earlier and more intensive supplier involvement. At the same time, high risks associated with new product technologies often compel managers to thoroughly test product technologies before investing in process design. This provides a counterforce for involving suppliers late and results in late and costly resolutions of manufacturing issues. Although there are clearly potential benefits associated with a more sequential approach to product and process design in highly innovative projects, manufacturing problems may not be avoided because little time or opportunity to fine-tune the product design or manufacturing processes is created.

Besides earlier involvement, high degrees of product innovation may increase the need for activities and mechanisms that bring in relevant information on technologies in advance or early in the development process. McDermott and Handfield (2000) argue that in a radically innovative project a different set of both internal and externally-oriented activities is needed to realise the technological breakthrough compared to projects which are characterised by incremental innovation. They suggest that, *'Project managers must involve purchasing personnel in helping to identify potential suppliers with a demonstrated record that offer technological solutions to meet market needs. Informal discussions with suppliers can often provoke greater interaction and synergies with* *internal design engineers, thereby leading to innovative technologies. To achieve these synergies, organizations must be careful to promote trust, information sharing, and alignment of technology roadmaps with core suppliers, in order to capture the full benefits of this integration (McDermott and Handfield, 2000; 54)'.* Ragatz et al. (2002) argue that the higher the degree of novelty[6] of the product and process technologies, the earlier companies need to bring in relevant supplier expertise and deploy mechanisms to allow intensive communication and information exchange to take place. These mechanisms include supplier participation on the project team, cost information sharing and technology information sharing. The study found some preliminary evidence that under conditions of high novelty these practices allow several development targets to be improved and offset the negative cost performance that would result if these mechanisms were not deployed (Ragatz, 2002).

We can use these insights to develop propositions regarding the need for managerial activities. First, a project team developing a radical innovative project may have a stronger need for product management activities such as suggesting new technologies available in supplier markets. Moreover, project management activities may be more relevant. The identification of how those portions of the total system are planned for various degrees of supplier involvement becomes more difficult since it concerns a new product and/or process technologies. It involves careful analysis, based on the in-outsourcing policy where external knowledge and expertise will be necessary and pursued. Therefore the develop-or-buy decision is likely to become an important activity. Similarly, the selection of potential candidates may require the use of different selection criteria to ensure that the suppliers have the required innovative and prototyping capability. Furthermore, highly innovative projects may increase the need to carefully determine *when* specific external knowledge should be brought in. The specific moments depend on the part characteristics, but the importance of analysing when to involve suppliers seems to increase with the complexity and innovative character. The need for specific co-ordination mechanisms horizontally and vertically may be required at the same time. Examples include the co-location of first tier suppliers and the periodic presence of crucial second tier suppliers that provide critical and new components in the part of the first tier supplier. To summarise, we expect some of the supplier interface management activities and all of the project management activities to become increasingly important in a highly innovative project.

Relationship driving factors

Relationship driving factors are those factors that bring complexity, uncertainty and novelty into the relationship with a supplier. Compared to the previous factors they provide the most direct clues as to what collaboration mechanisms are most appropriate to address the risk surrounding the collaboration. These factors therefore increase the need for project and

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[6] Product and process novelty are part of an overall measure for the technological uncertainty of a project. Technological uncertainty is measured in terms of the degree of novelty of the product and process technologies, the complexity of the technologies and the degree to which these technologies are subject to change.

product management activities. More specifically, they affect the appropriate structure of the buyer-supplier interface in a specific collaboration (during the development of a part). A higher degree of presence of these risks implies a lower chance of achieving one or more project objectives. We have identified the following collaboration driving factors: (1) '*development complexity*', (2) '*development novelty*', (3) '*technological uncertainty*', (4) '*availability of alternative supply sources*' and (5) '*importance to the overall product's functionality'*.

Figure 3.4 and Table 3.2 gives an overview of the hypothesised relationships and the factors.

Figure 3.5 Identifying relationship level driving factors

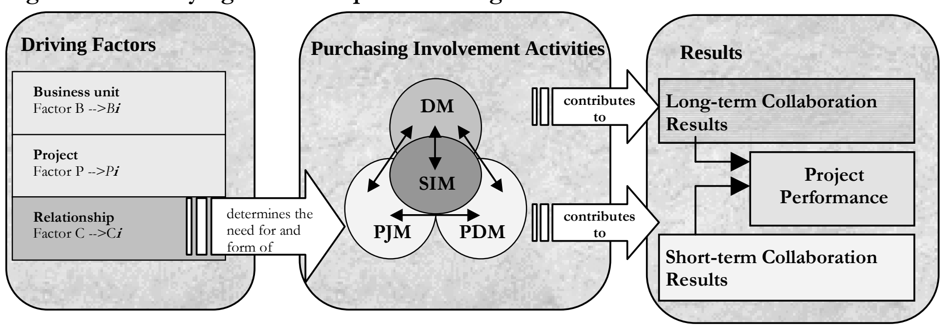


Table 3.2 Driving factors

Driving factors	Increases need for	Authors
Business Unit level driving factors		
▪ Degree of market uncertainty (in end market)	DM and SIM	Eisenhardt and Tabrizi (1995)
▪ Degree of technological uncertainty	DM and SIM	Eisenhardt and Tabrizi (1995)
▪ Business unit size	DM	Wynstra et al. (2000)
▪ Supplier dependence	SIM	Wynstra et al. (2000)
▪ R&D dependence	DM and SIM	Wynstra et al. (2000)
▪ Production complexity	PJM/PDM	Wynstra et al. (2000)
Project level driving factors		
▪ Degree of Project complexity	PJM/PDM	Swink (2001), Lakemond (2001)
▪ Degree of Project innovation	PJM/PDM	Clark, 1988; Henderson and Clark 1990; McDermott and Handfield (2000), Ragatz etal., 2002; Tatikonda and Rosenthal (2000)
Relationship level driving factors		
▪ Part development complexity	PJM/PDM	Laseter and Ramdas (2002), Wynstra and Ten Pierick (2000)
▪ Part development novelty	PJM/PDM	Hartley et al. (1997), Wynstra and Ten Pierick (2000)
▪ Part technological uncertainty	PJM/PDM	Wasti and Liker (1997), Handfield et al. (1999) Laseter and Ramdas (2002)
▪ Availability of alternative supply sources	PJM/PDM	Wasti and Liker (1997)
▪ Importance to the overall product's functionality	PJM/PDM	Wynstra and Ten Pierick (2000)

(1) Part development complexity

A first factor that may present a risk to the attainment of the development objectives is the *complexity of development* of a specific part. This complexity may stem from the degree of *part interdependence* (external complexity) or may stem from the *technical complexity* of the internal part to be developed (internal complexity). We already measured complexity at the project level as the degree of interdependence of tasks. However, several authors also argue for an assessment of complexity at the part level. This means that the interdependence of a given part can be determined as opposed to an overall assessment of all components. One way of assessing this interdependence is to understand to what extent a part determines the technical specifications and the design of other parts (Wynstra and Ten Pierick, 2000). Laseter and Ramdas (2002) therefore measure the number of interfaces of the sourced product and the degree of predictability of the interaction with other parts (e.g. system interactions/physical interfaces).

The implications for the appropriate activities to manage this involvement are numerous. Ramdas and Laseter argue that the development of a component possessing a high degree of interdependence requires tighter integration of the supplier into the overall product development process. Similarly, Sobrero and Roberts (2002) suggest that high task interdependence of one part with others poses risks in terms of achieving the development targets if those development tasks and the communication between the project team and the supplier are insufficiently co-ordinated. In terms of the need for the management activities, we argue that a part with a strong interdependency may require early involvement of a supplier if information about some specifications is needed. Furthermore, the associated need for communication requires intensive co-ordination to cope effectively with possible changes in the interface or in the design of the part.

In addition to part interdependence, the *technical complexity* of the part in isolation is regarded as a factor influencing the way supplier involvement should be managed. For example, the more components the more effort and knowledge of the linkages need to be brought in to design and manufacture the part. The development complexity can also be said to increase when the number of different product and production technologies involved increases (Wynstra and Ten Pierick, 2000). The knowledge and their combined interactive use require more design and engineering knowledge, which makes it more complex than mono-technology parts. Again, if this complexity is well anticipated it may lead to increased search efforts and assessments of suppliers that have relevant experience or can be otherwise judged as being capable of bringing in relevant expertise for the development of the component. Furthermore, depending on the availability of internal technological knowledge and development expertise, the supplier needs to be involved earlier and must have a larger development responsibility than for low-complexity items.

(2) Part development novelty

In addition to part development complexity, the collaboration with individual suppliers may be subject to increased risks if the involved team members of the buyer or supplier are unfamiliar with some aspects of development. We introduce the *novelty of these development aspects* as a driver.

Hartley et al. (1997) refer indirectly to the *novelty of the component* as a source of development risk. They argue that the degree of component change entails uncertainty for the project. With a standard or slightly modified component, a supplier can build upon previous experience and thus avoid unforeseen problems better than in a situation when designing completely new components. Wasti and Liker (1996) have measured this in a slightly different way by the extent of change in the design of the component since the last model. The *novelty of these development aspects* can refer to *product* or *process technologies*, or to the way components are internally linked in the part or to the *application of the part in the final product*. The main argument for assessing novelty both for the project as a whole and concerning a specific part is the fact that the degree of project innovation may not be the trigger for a more active execution of certain management activities, but the fact of whether the novelty is present in a specific collaboration when developing a specific part. Within an overall radical innovative project there still may be parts that are relatively standard. Hence, such suppliers may be involved later and less intensively. A similar reasoning applies in the other direction. A small number of parts may require intensive development activities between the buyer and supplier even though the part is located in an incrementally innovative product.

(3) Part technological uncertainty

The development of a component may be confronted by different levels of externally generated *technological uncertainty* in the supplier market that put the attainment of the development targets at risk if this uncertainty is not properly anticipated, analysed and dealt with. Laseter and Ramdas (2002) refer to the degree of technological change that is occurring in supplier industries for particular parts. They argue that sourced products experiencing a rapid rate of technological change may require more frequent design updates and closer supplier-OEM integration in order to quickly capture the benefits of improved technology. For instance, the uncertainty may result in *component obsoleteness* if it is not properly anticipated and no proper and frequent information exchange occurs between the buyer and supplier or with other sources. This can later result in delivery stops or significant redesign costs. In a similar vein, Handfield et al. (1999) argue that this uncertainty has an impact on the moment of involvement. One way of dealing with the uncertainty is to shift to modular design and postpone the technology choice until late in the project; this would allow the latest technology to be adopted frequently and at low cost.

(4) Availability of alternative sources of supply

Another source of external uncertainty has been suggested by Wasti and Liker (1997) in terms of the *'availability of alternative sources of supply'* for a particular part. They found that high availability is associated with a low level of supplier involvement. Although they found some companies actually intentionally limiting alternative supplier sources, they could indicate the need for risk reducing activities. For example, the search for alternative technologies may become an important activity in the face of a monopolistic situation. Furthermore, the standardisation of components can reduce the complexity and increase the total production volume of components for one supplier.

(5) Degree of new contribution to the overall system's functionality

Besides knowing the sources of risk, project teams need to prioritise their attention to managing the collaboration based on knowledge of the impact of such risks. The contribution of the part to be developed with the supplier on the overall product's functionality (Wynstra and Ten Pierick, 2000) may put extra emphasis on achieving reliability and durability of that part. Moreover, a high perceived contribution requires extra and early attention to ensure the development time of the part does not endanger the overall planning. The costs of not meeting the targets may be much higher in terms of lost sales and service calls.

To summarise, we argued that a set of different organisational and market variables at different levels of analysis represent sources of risk for a company. By reading the characteristics of their external market and internal organisational characteristics, companies can deploy an appropriate set of management activities to address these risks. Identifying business unit, project and relationship drivers helps us to better understand which groups of managerial activities need to be carried out to a higher extent. All these different sources of development risk may require more activities to be carried out in one or more of the four management areas through which these risks can be curbed!

3.3.3 Introducing additional enabling conditions

In addition to the proposed addition of contextual characteristics and their conceptualisation at three levels of analysis, we similarly propose to distinguish between enabling factors in terms of three different units of analysis: *internal*, *external* and *relationship enabling factors*. Table 3.3 presents the suggested factors.

In the literature review a number of factors have been suggested that may present conditions necessary to realise an effective and efficient supplier involvement. Analysing the cluster of factors identified by Wynstra (2001) in the Purchasing Involvement Framework, these factors predominantly refer to structural (e.g. purchasing organisation) and resource characteristics (e.g. information/infrastructure and human resources). These characteristics have in common that they pertain to internal conditions that help a company to organise supplier involvement in product development. We therefore refer to them as 'internal enabling factors'. However, their presence does not guarantee a successful supplier involvement. The literature review revealed that some factors, playing a crucial role in the performance of supplier involvement, can be found either at individual suppliers ('external enabling factors') or within the specific collaboration between the manufacturer and supplier ('relationship enabling factors').

Table 3.3 Enabling factors

Internal Enabling factors	Facilitates the execution of	Author
Internal Enabling factors		
▪ Internal organisation of the purchasing department and development team	DM/SIM/PJM/ PDM	Wynstra (2000), Burt & Soukup (1985)
▪ Recording and exchange of information	SIM/PJM/PDM	Wynstra (2000)
▪ Quality of human resources	DM/SIM/PJM/P DM	Anklesaria and Burt (1987); Guy and Dale (1993); Atuahene-Gima, (1995) ; Dobler and Burt, (1996) Wynstra (2000)
External Enabling factors		
▪ Supplier technical capabilities	PJM/PDM	Wasti and Liker (1997), Hartley et al. (1997), Birou and Fawcett (1994)
▪ Supplier's suppliers network (access to capabilities in the network)	PJM/PDM	Håkansson and Eriksson, 1993
Relationship Enabling factors		
▪ Past experience of collaborations	PJM/PDM	Wasti and Liker (1997), Hartley et al. (1997) Farr and Fisher (1992), Bruce, (1995); Dyer and Ouchi (1993)
▪ Compatibility of Culture/operating style	PJM/PDM	Contractor and Lorange (1988), Perlmutter and Heenan (1986), Bruce et al. (1995)
▪ Trust - Social Climate	PJM/PDM	Sako (1992), Gabarro (1987), Dyer (2000) Bensaou (2000)

Internal enabling factors

The literature review does not clearly suggest empirically investigated factors that can be connected to the internal enablers in addition to those identified by Wynstra (2000). We have therefore not (yet) added any internal enablers.

External enabling factors

Besides the factors that can be found in the internal organisation of the buying company, several studies have suggested enablers that can be found externally and which support the development of a part. We identify the technical capabilities and the access to supplier's networks as specific enablers.

Supplier technical capabilities

The literature provides the strongest evidence that a supplier's technical capabilities are a prerequisite for effective involvement in a development project. Wasti and Liker (1999) indicate that the technical capabilities are a strong indicator for earlier supplier involvement. Zirger and Hartley (1997) found a significant relationship between high technical capabilities and reduced project cycle time. 'Outsourcing design responsibility to a technically capable supplier could accelerate the development process, but if a supplier is weak technically, major delays could be encountered because of design errors that necessitate repeating the process' (Hartley et al. 1997). Handfield et al. (1999) suggest that suppliers must also have the organisation and processes to meet specific customer's targets. It is important to note that a technical capability in isolation will not be valuable to the manufacturer unless it is viewed as being compatible with the customer's need and the specific component demands and characteristics within a specific collaboration instance.

Supplier's cooperation with other own suppliers and other manufacturers

The capabilities residing in the network of the first tier supplier is a factor that can enable a specific collaboration to meet the development objectives (Håkansson and Eriksson, 1993, Von Corswant and Tunälv, 2002; Araujo, Dubois and Gadde, 2003). For example, a supplier developing and assembling a complex part may not have the production of certain components in-house, but has created a network of suppliers with specialised component production capabilities. Therefore, by developing a direct relationship with one supplier, the buyer can create indirect access to a network of specialised capabilities that it cannot or does not want to access directly. These suppliers may bring in expertise which the manufacturer does not have (anymore). In a similar vein, the cooperation with other manufacturers helps a supplier to stay updated, learn new technologies and view its own development results more critically (Von Corswant and Tunälv, 2002; 255). However, one should be aware of possible knowledge leakages to competitors; such knowledge transfer must therefore be limited.

Relationship enabling factors

So far, we have specifically discussed the enabling factors for the efficient and effective execution of integrated product development and sourcing activities that are internal and external to a particular company. We argue that the collaboration between the customer and supplier is also supported by the way that the customer and supplier are able to exchange resources. We identify the following relationship enabling factors that exist only in the active relationship between the buyer and supplier: (1) past experience of collaborations, (2) compatibility in culture/operating style and (3) mutual trust.

Past experience of collaborations

An important enabler that can assist in achieving a successful outcome has been the presence of previous experience of collaborations (Bruce et al., 1995; Farr and Fisher, 1992). A history of working together with a particular supplier helps to make a more efficient and effective collaboration, because each experience provides the opportunity for the supplier to gain knowledge of the buyer's organisation processes and requirements. Understanding a customer's needs helps a supplier to avoid time-consuming product and process redesigns. Their prior experience may enable them to anticipate where some problems occur (Hartley et al. 1997). Furthermore, prior experience facilitates the suppliers' own project planning and its building of customer-specific capabilities that enable that supplier to meet its customer's needs more effectively (Asanuma, 1989; Wasti et al., 1999). Other authors emphasised that it is the long-term relationships and commitments with frequent planned communication, which reduce transaction costs and eliminate inter-company inefficiencies (Dyer and Ouchi, 1993).

Compatibility in company culture and operational style

The role of culture in customer-relationships has been addressed to some extent in previous research. Both differences in national, corporate and professional cultures have been argued to be a potential source of misunderstanding for internal and external relationships. In relationships between two companies from different nationalities, in particular, cultural and language differences have been said to lead to operational difficulties (Perlmutter and Heenan, 1986). Regarding corporate cultures, Bruce (1995) argues that compatibility of culture embraces operating and management styles. This refers to 'an understanding of each other's behaviour and objectives' and an 'appreciation of each other and being willing to accommodate and adjust to another's point of view'. Referring to strategic alliances Lorange (1998, pp.) argues, '*The member organisations must be able to communicate with each other, having a language that they all understand. They must have a working style which is complementary in the way they go about reaching decisions, their problem solving style and so forth. Above all their behavioural styles must be compatible.'* Professional cultural differences can be argued to exist when two groups of persons from two disciplines internally or externally share/adopt different working practices and have different interests or objectives.

Mutual Trust

The role of trust in customer supplier relationships has been widely regarded as a condition and therefore as an enabler for effective buyer-supplier (inter-company) relationships (Håkansson, 1982; Spekman, 1988; Ford, 1990; Morgan and Hunt, 1994; Ring and van de Ven, 1994; Sako, 1992). Product development is generally viewed as a process dealing with uncertainties and interdependencies. Managing interdependencies with suppliers involves certain vulnerabilities, as the other party may exploit the dependent company. Instead of solely relying on contracts, which can entail the enormous costs of writing and enforcing them upon the other party, collaboration in product development can be facilitated by the presence of mutual trust between the buyer and supplier. Dyer (2000) argues that, especially in uncertain situations, trust facilitates investments in dedicated assets and enables the achievement of lower transaction costs and a higher knowledge sharing. It may therefore be a more efficient mechanism to govern the exchange during product development.

Trust has been viewed in various ways. Rousseau et al.(1998; 395) formulate a widely regarded definition of trust as, '*Trust is a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behaviour of another person'*. However, it has mainly been considered as a complex and multi-dimensional construct. Ring and Van de Ven (1994; 93) note that two views have been popular in management and sociological research. The first view adopted is a business risk view, based on confidence in the predictability of one's expectations (Luhmann, 1979; Zucker 1986). The second view is a narrower view based on the faith in the moral integrity or goodwill of others. Goodwill appears to be a common element in many views. For example, Sako (1993) distinguishes between contractual, competence and goodwill trust. Dyer argues that trust is one party's confidence that the other party in the exchange relationship will fulfil its promises and commitments and will not exploit its vulnerabilities. Trust is therefore based on three components: reliability, fairness and goodwill. An interesting view on trust is provided by Gabarro (1987). He identifies two basic trust dimensions: character and competence-based trust. Character-based trust examines qualitative characteristics of behaviour inherent in partners' strategic philosophies and cultures; competence-based trust examines specific operating behaviours and day-to-day performance. There are five sources of character-based trust: (1) integrity- the partner's level of honesty and principles; (2) identification of motives – the partner's true strategic intentions; (3) consistency of behaviour – the reliability and predictability of the partner's actions in different situations; (4) openness – the partner's willingness to be honest about problems; (5) discretion – the partner's willingness to maintain confidentiality of strategic plans and key information (Gabarro, 1987). Gabarro (1987) identifies four sources of competence-based trust: (1) specific competence – specialised operational knowledge and skills; (2) interpersonal competence – an individual's ability to effectively perform his or her responsibilities and work well with others; (3) competence in business sense – a broad experience base beyond a specific area of expertise; and (4) judgement/decision-making ability. He combines the business risk and goodwill view on trust in the character-based trust construction, but adds a valuable dimension by introducing competence-trust. Trust must be present since both parties depend on each other to satisfy mutual short-term and long-term goals (Whipple and Frankel, 2000). Certainly in intensive collaborations between the buyer and supplier, critical information may need to be exchanged. As such, sufficient character-based trust allows this exchange to take place supporting the achievement of long-term goals (i.e., the timely availability of new technologies aligned with planning of future development projects). Competence-based trust is an important condition for sufficient commitment among various managers and project members to allow high supplier involvement collaborations. Several authors have mentioned top management commitment as an enabler that is closely connected to the concept of trust.

Moreover, trust may be both an outcome and simultaneously be something that is continuously being built on. Several practices and actions of both parties can alter the level of trust that two parties have in each other and can affect the outcome of a collaboration in product development and the willingness to collaborate again next time. Developing trust can therefore be regarded as a relationship-specific skill or asset in itself (Asanuma, (1989) quoted in Sako, 1993). Increasing trust creates and sustains the level of commitment that both the buyer and supplier display to each other. Several trust enhancing practices have been suggested, such as a transparent supplier selection process, co-location of suppliers in cross-functional product development teams and supplier assistance in improving processes (Dyer, 2000). We continue to consider trust to be an important enabling condition consisting of 'character-based' and 'competence-based' trust. Both are affected by actions and events in the relationship between the buyer and supplier. Absence of mutual trust can affect the commitment for a particular collaboration and subsequently undermine both the short-term and long-term outcome.

As a final remark we focus on the positive association between enabling conditions and the effective management of supplier involvement. We assume that the higher the presence of an enabling factor the stronger the positive relationship between the managerial activities and the results of supplier involvement. Although authors such as Handfield (1997) and Monczka (2000) speak of barriers to supplier involvement/integration, we argue that an *absence* of an *enabler* can be regarded as the *presence* of a *barrier,* or at least is conducive to the emergence of a barrier. For example, a lack of trust among certain buyer representatives (e.g. R&D) can hinder the progress of the development and undermine the disposition to future collaborations with the supplier. Furthermore, the lack of a cross-functional organisation may signal the lack of an outward looking R&D organisation, which in turn may point to the existence of the barrier often referred to as the 'Not-Invented-Here' syndrome (Katz and Allen, 1982). The latter indicates an attitude in the (R&D) department organisation that no better ideas can come from outside the company.

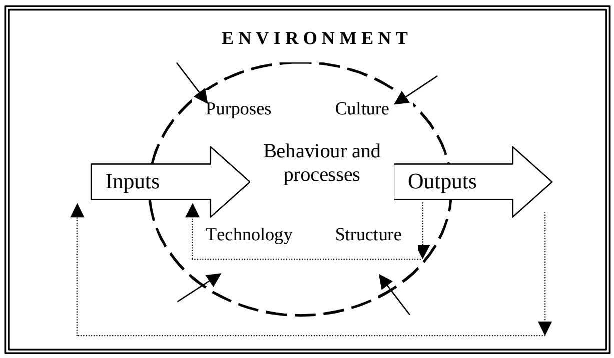
3.3.4 Purchasing involvement becomes Integrated Product Development and Sourcing

As a fourth adaptation, we propose to replace the name of the original Purchasing involvement framework by the framework for Integrated Product Development and Sourcing. At first glance, the reference to 'purchasing' suggests an emphasis on the managerial role of the purchasing department. While determining each department's responsibilities and role is important, we argue that an a priori choice of one actor or apparent reference may bias our view. We therefore want to exclude this a priori perspective and argue that different task partitioning configurations across different actors, internally and externally, may be equally effective for different companies. Managing supplier involvement concerns the integration of several purchasing or sourcing-related activities with product development activities. Wynstra specifically argues in his later work that, *'Successful Integrated Product Development and Sourcing (IPDS) consists of a number of closely-related activities that are carried out at different levels in the organisation, and which have different time-horizons. Integrating and co-ordinating the activities throughout the organisation and synchronising short and long-term activities is of crucial importance (Wynstra, et al., 2002; 165).* We therefore argue that purchasing involvement and managing supplier involvement needs to be extended to a framework that describes conditions, management activities and results from an 'Integrated Product Development and Sourcing' perspective (IPDS).

3.3.5 Integrated Product Development and Sourcing as an Open Systems model

So far, we modelled the organisation and management of supplier involvement as the presumed causal relationships between antecedent conditions (drivers and enablers), managerial activities and short and long-term collaboration results. We can view this way of modelling as an application of the Open System modelling of organisations in general (Katz and Kahn, 1978; Harrison, 1988). Open System Theory views organisations as a constituent system of elements transforming inputs via behaviour/processes and technology into outputs in interaction with the environment in which it operates. Harrison (1988) identifies the following elements in the Open System Model (OSM): Outputs, Behaviour and Processes, Inputs, Technology, Purposes, Environment, Culture and Structure (see Figure 3.6).

Figure 3.6 **Open Systems Model** (Harrison, 1988; 24)

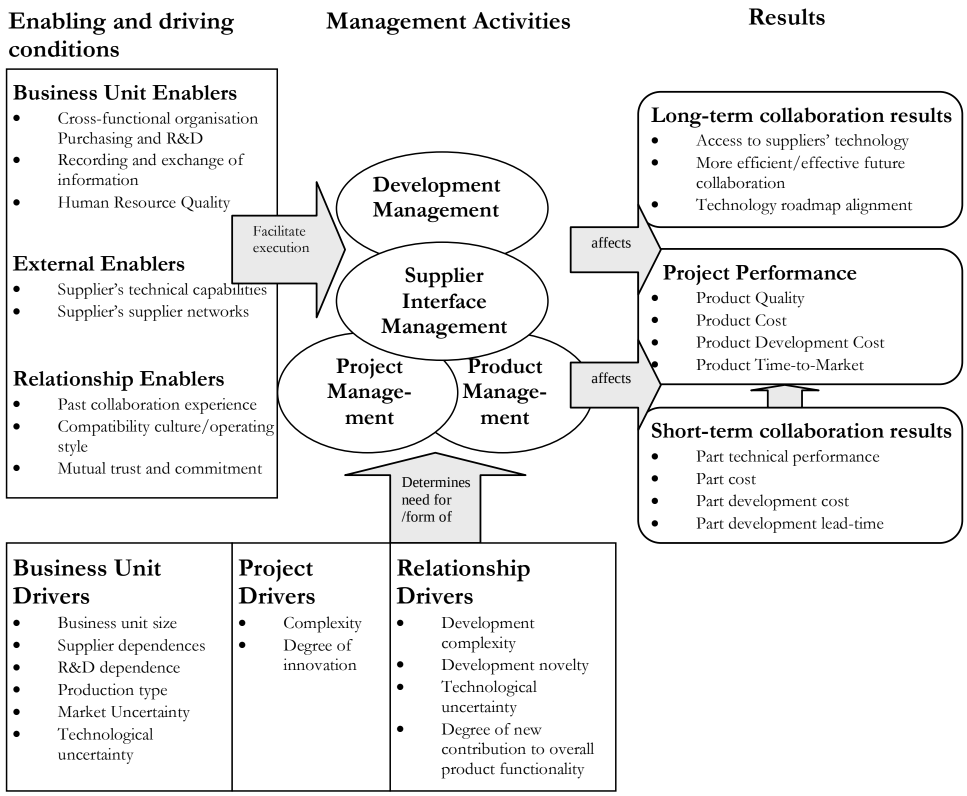


We argue that the IPDS framework has similarities to the Open Systems model. The latter has an Input, Throughput and Output logic. The output part consists of three main output areas that have different time horizons during which these effects become visible. Output is usually referred to as the services, components and products delivered. However, we have decided to focus on the attainment of pre-set targets that provide us with a related measure of effectiveness and efficiency with which this output is achieved. These sub output areas are the 'short-term collaboration results' and are also their contribution to the overall project development performance. We have also included the long-term collaboration results in the output part. These benefits are the result of the processes and behaviour that are in place to transform the input (enablers). The processes and behaviour are comparable to activities that have been identified in the four management areas. These activities include decision-making processes and the underlying behaviour of various actors. The technology element in the OSM, which includes the methods and processes for transforming resources into outputs, also bears a resemblance to the IPDS activities to manage specific parts of supplier involvement.

One of the differences with the Open System Model is related to the interpretation of inputs. The OSM views inputs as the resources, such as capital, materials, buildings etc. that are used in the transformation towards the desired outputs. We consider inputs to be the conditions for effective management of supplier involvement. However, enablers and drivers affect the managerial activities in two different ways. First, enabling factors can be regarded as a specific type of input or set of resources that *facilitate* the execution of the managerial activities by supporting speedier and more effective decision-making activities. We note the overlap so far in terms of human and information resources, but have not yet incorporated monetary resources or buildings and physical materials as inputs. Secondly, although the OSM distinguishes the context from the inputs, driving factors provide the signals for the company to carry out the managerial activities *more actively*. For example, the technological uncertainty is a condition in the general environment that a company is operating in, and acts as a contingency to increase the resources on monitoring technological developments in supplier markets.

Although not in a literal sense, we consider enablers and drivers to be two different types of input factors that affect the ability and the need or form of the activities to manage supplier involvement. All proposed adaptations have been summarised in Figure 3.7.

Figure 3.7 Revised framework: Integrated Product Development and Sourcing



3.4 Conclusions

In the previous chapter we observed that suppliers' contributions in the product development process could improve the product development performance. However, we argued in favour of a more integrated and detailed view of the opportunities for achieving these improvements and of the way the involvement of suppliers is effectively managed. An emerging view from literature is that the realisation of these benefits depends on the characteristics of the (task) environment in which a company is operating and the way the company interacts with suppliers and manages their involvement. It is here that a fragmented view exists on managing supplier involvement in product development. The literature has not provided sufficient insight into the managerial activities that are needed to organise and direct the involvement of suppliers in the 'short-term', i.e. within development projects, and in the 'long-term', i.e., between consecutive development projects over time. We identified the need to develop an integrated contingency-based framework for managing supplier involvement, which would be suitable for subsequent exploration and empirical testing. We therefore analysed the 'Purchasing involvement framework' to find out the extent to which it allows us to empirically investigate the research questions. We discussed the exact meaning of the various elements of the 'Purchasing involvement framework' in detail. We then concluded from our literature review that the framework needed five adaptations in order to analyse in an integrated way (1) the input conditions in which supplier involvement in product development takes place, (2) the activities that are relevant to manage supplier involvement in the short and long-term, and (3) the short and long-term results of these managerial activities. We added two different clusters of supplier involvement effects to the framework and modelled their presumed impact on product development performance and their strengthening effects on the input conditions for future collaboration.

We also identified additional input conditions at different levels of analysis. Driving factors were identified at the business unit, project and collaboration level. Moreover, enabling factors were added and connected to three different units of analysis: the internal organisation, the external supplier organisation and the collaboration. We renamed the framework as the 'Integrated Product Development and Sourcing' framework (IPDS). The main reason is that managing supplier involvement is viewed as more than the involvement of suppliers in single projects. Supplier involvement is a phenomenon that concerns the interplay between innovation and supply. In that respect, purchasing involvement has a biased connotation since it does not directly emphasise the cross-functional and process nature of this interplay. Finally, in combination with contingency theory, the Open Systems Model provides a theoretical anchor that allows us to study the phenomenon of managing supplier involvement a specific part of organisations and acknowledging its dependence and need to adapt structure and processes to its environment.

In the next chapter we use the IPDS model to empirically investigate the critical activities and conditions that underlie the achievement of the desired supplier involvement results.

Chapter 4
Managing supplier involvement in product development in a high-tech company: Case Description

The company' s innovative capacity is broadened and reinforced on an ongoing basis via alliances with strategic partners and via systematic co-operation with co-developers and suppliers. (Océ annual report 2002)

Chapter four presents the longitudinal case study in which the Integrated Product Development and Sourcing framework is used to analyse the effectiveness of the activities and conditions supporting the management of supplier involvement in eight different collaborations between the manufacturer and supplier in product development. We first outline the context of the case studies in terms of the industry characteristics and dynamics, followed by the characteristics of the company itself. Next, we describe the case study design and the methodology adopted. We argue why the copier and printer industry, and the company in our case study in particular, were appropriate as a context to study 'supplier involvement in product development'. Finally, we build eight case studies concerning the collaboration with suppliers in product development at Océ. At the end of this chapter we discuss and distil the development outcomes and main issues and problems, preparing the case material for analysis in the next chapter in terms of results, managerial activities and conditions.

4.1 Industry context and dynamics 1990-2003

We have chosen the copier and printer industry as the context in which to study the management of supplier involvement in product development. The printer and copier industry is characterised by the development of highly complex products. Copiers and printer products are in general in the mature phase of the product life cycle. However, the industry is still subject to technological change that allow product and service innovation to take place. This characteristic makes the investigation even more interesting; Quinn (1994) argued that supplier involvement is becoming more important since it is becoming increasingly difficult to keep up with technological developments when relying primarily on in-house knowledge development. The copier manufacturing industry emerged before printers were developed, after the invention of the first xerographic copier by Xerox in 1949 (www.xerox.com). Since then the products have undergone incremental technical, reliability and speed improvements in addition to the introduction of several features. The main players in the office copying market segments remained the same for many years: market leader Xerox was followed by Kodak and several Japanese companies such as Ricoh and Canon. Several niche markets were occupied such as mid and high-volume copiers and engineering copiers. Two trends, starting in the second half of the 1980s, have contributed to a transformation of the products/markets and the industry structure. The first is *digital technology*, which has enabled a formidable technological transformation during which companies started developing printers and, somewhat later, digital copiers and hybrids instead of analogue products. The second trend was that several companies worked hard to provide a *cost-effective colour technology* as an alternative to the dominant black and white copying technology. According to US analyst Larry Hunt (1999), in 1999 colour copying already occupied 10% of the high-speed copier market volume. Dataquest estimated the annual growth in the overall colour printing and copying market at 45% (Management Team 3-12-'99). These trends spurred a number of developments that led to intensified and new competition. The first development was the improvement of copying quality, for example by digitally manipulating scanned images. Digitisation also removed the barriers within the copier and printer markets and blurred the definitions of future document-output products (Dataquest Perspective, 1999). These days customers increasingly choose machines that combine scanning, printing and copying functions. The first generations of digital copiers were stand-alone machines. The next generation of copiers were connected to PCs, however, and therefore increasingly had to be linked to the company's existing computer network (Dataquest, 1999). Digitisation provided an enormous opportunity for developing new features in networked copiers. These features were enabled by software. Examples include print job management, printing on demand and remote servicing. This software allowed companies to develop new services provided on top of the hardware copier/printer product itself (ref: Océ marketing manager). A study by the US "Xplore Institute" regarding the inefficient document handling and processing activities of companies argued that 15% of a company's turnover is lost on searching and distributing documents. Companies have therefore increasingly chosen to develop new facility services, including document management consultancy, and to develop solutions for the content management of documents[7]. The convergence of the printer and copier markets has enlarged the set of potential competitors: printer manufacturers such as Hewlett Packard and Lexmark had to be considered as players in the same market segments as the copier companies were active in. Moreover, renewed consolidation in the copier and printer market has been observed and numerous alliances with software companies have been set up (Dataquest, 1999). It is in this context that we have found printer manufacturer Océ willing to work with us on a longitudinal case study on how supplier involvement can be effectively managed from a buyer perspective. We now introduce the company background in terms of its products, markets and strategy.

4.2 Company background

Before looking at the specific case studies we describe the company characteristics to sketch the initial context in which the cases take place. We have chosen to consider a 10 to 15 year period as the relevant time frame to describe the main strategic changes, its organisational structure and the challenges faced by Océ. This study does not intend to describe the larger

[7] Content management covers the following five areas:: documents need to be created and captured, stored and managed, searched and accessed, distributed, and managed in terms of administrative rights (Gartner Group, 1999).

community of actors that may have played a role in stimulating, preventing and transforming the industry and/or company.

4.2.1 Products, Markets and Strategy

Océ is a Dutch manufacturer and provider of a wide range of products and services that enable professional customers to manage their documents efficiently and effectively by offering innovative print and document management products and services for professional environments. Océ has been primarily targeting segments such as departmental, central reprographic document processing, electronic data processing (printing salary slips, telephone bills) engineering (wide format printers for CAD and architectural drawings), print shops and publishing environments (books, billboard posters). Océ's roots are in the manufacturing of margarine dyes; they subsequently moved into copying and then printing activities. These roots have laid the foundations for its own unique copying and printing technology[8], on which a majority of its products are based. Océ has more than 22000 employees; its revenues exceeded three billion Euros in 2002 (Annual report 2002). Two characteristics differentiate Océ from its competitors in its main markets. Firstly, Océ has built its market position by investing heavily in R&D and developing its own, unique technology base. Secondly, it is considerably smaller than most of its main competitors. Their typical production series range from 1,000 to 10,000 pieces per year, whereas production numbers of 100,000 machines per year are typical for their competitors. As a result of these two characteristics, Océ is under pressure to define its market very clearly. Océ's unique technology is considered to be very reliable but relatively expensive for low volume segments, and therefore fits high volume professional markets, where reliability and productivity (low cost of ownership) are of importance. The development of new products and technologies is supported by relatively large R&D investments; in absolute terms there is no comparison with the competition. For example, Xerox Corp. invests $1.5 billion in R&D, Canon Group invests $1.8 billion in R&D, and Océ invests $160 million (Annual report 1999). However, in 2001 Océ still occupied a shared 4th ranking in terms of its share of annual R&D budget of total turnover.

Table 4.1 R&D size versus competition (Source: annual reports, 2001)

Main companies active in copier and printer markets	% of annual turnover (Budget R&D Total)
Heidelberg	8.6%
Canon	7.5%
Fuji Xerox	6.8%
Océ	6.3%
Xerox	5.9%
HP	5.9%
Ricoh	4.8%

[8] Océ's unique technology is related to its patented copy press system, its colour technology and the unique way of projecting the image and the toner on the organic photo conductor. This process is based on a 'white writing principle' compared to the dominant 'black writing technology' used by its main competitors.

4.2.2 Organisational structure

Océ operates in the professional printing markets using a business unit structure which has profit centres that are defined in terms of a set of related coherent market segments. Besides the business units, there are over 80 operating companies. These operating companies sell the products that the business units make available, and are accountable for the sales and profit volumes in their designated country (or countries). The business units can subcontract the development and manufacturing of a new product internally to the R&D and Manufacturing unit, or can decide to acquire a readily available product in the market (from competitors). The corporate board supervises this process. The R&D organisation has been subject to a number of changes during the past 10 years. The most striking characteristic is the matrix organisation in which the project organisation is supported by the functional resource organisation. Functional organisation includes a small group that focuses on technology development, and which is strongly focused on core printing and copying technologies. Several functional disciplines have also built up development and engineering expertise in mechanical, electronic, and increasingly IT-related areas such as software and controllers. These disciplines ensure that different product functions are designed, engineered and integrated in a product according to the project definition. A significant number of the functional members are therefore allocated to product development projects. The R&D thrives on a large project organisation in which a small development group and a large group of engineers are involved during partially overlapping stages in a development project. Purchasing is a support department within the overall Océ organisation. It has always reported to the Director of Manufacturing and Logistics. Purchasing's role in the overall organisation has been primarily supportive in obtaining the parts from suppliers needed for internal production, while managing different supply risks and striving for optimal commercial conditions. The purchasing department can be divided into two sub-departments: 'Purchasing Machines' and 'Consumables Facilities and Investments' (CFS). Purchasing Machines employs between 20 and 30 buyers, and is responsible for sourcing and procuring parts that remain part of the final machine. CFS is responsible for the process of strategic and initial purchasing of 'IT and Investments', office supplies, and strategic consumables, such as toner and ink for copiers and printers.

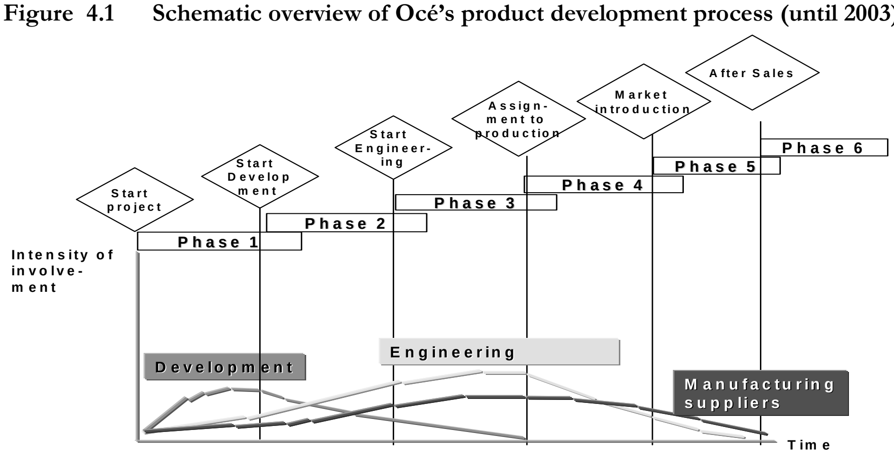
4.2.3 Product development process

Océ has been working according to a concurrent stage gate product development model. We will describe the model that Océ was using in the period until January 2003 when the main cases took place (see Figure 4.1). This 'old' model is relevant as the background of the case studies. Six product development phases are identified:

- *Phase 1: Feasibility Study*: could the product be realised? (commercial, technological and resources risks will be identified) At the end of this phase the Board of Directors of Océ decides whether to commit to the realisation of the proposed product, through the project. Realisation becomes R&D's highest goal.

- *Phase 2: Process and Concept development*: Build a laboratory model for concept testing. Major technology choices and concepts are chosen.
- *Phase 3: Engineering*: Transfer the laboratory model to a production prototype. Engineering will take over the technology layout choices and will engineer (industrialise) the product towards the product release phase. R&D delivers a complete product document package to Operations Production and Logistics, Services and the Marketing department.
- *Phase 4: Transfer to production:* partial release and build of the machine in regular production. Production starts, responsibility for the manufacturing of the product is now in the hands of Océ's production organisation. Suppliers are formally approved for all parts. All necessary actions to provide continuity and quality are taken.
- *Phase 5: Market Introduction:* This point defines what the time-to-market is and signals the official start of supplying the customers.
- *Phase 6: Regular Production:* Keep track of and solve problems in 'the field'. Project organisation is dismantled.

Figure 4.1 Schematic overview of Océ's product development process (until 2003)



During the development process representatives from different departments gradually become more intensely involved. Studies on possible projects and project proposals are defined at the business unit management level. In the permanent cross-functional management team consisting of Production, R&D, Marketing and the Strategy Group directors, these projects are discussed and the business and technical case is built in further detail. All 'Product-market proposals' need to be approved by the Corporate Board. Purchasing issues at this level are mainly represented by the Manufacturing and Logistics director. After approval of a project, a project team would be formed, again with representatives from the different departments. The first three phases are strongly R&D-oriented, during which the technological feasibility of the concept and specific functions must be proven. R&D is responsible for developing the right technical product specifications to enable the Product/market project plan to be realised. At the start of the engineering phase, a specific project progress team is created to engineer the parts according to the functional and other design constraints, and to ensure the industrialisation and production ramp-up of the final product. This team consists of several R&D representatives, a Purchasing representative and Production and Service engineers. Purchasing usually sends a project buyer to the development team. He acted as a single coordinator to identify the number of purchasing components, and to communicate and assign the components to the relevant account buyers. Account buyers are grouped in several commodity teams that are specialised in different production technologies, such as sheet metal, rubber, plastics, electronics and specials. They are responsible for securing the timely supply of high quality parts to the production site at the most favourable costs, also taking into account life-cycle issues and other possible supply risks. The project buyer, who also has account buyer tasks, would then keep an overview of the part release progress, and signal any problems in time to the project progress team and also to the account buyers. The involvement of account buyers often starts by suggesting potential suppliers; the account buyer then act as the main contact person for communication with suppliers. This does not mean that all communication has to pass through him/her, but that he or she would expect to be informed about issues that could affect the progress or commercial position of the company.

4.2.4 Challenges for Océ

Océ's roots in chemistry, going back to 1877, have contributed to the growth and expansion of a product/technology-oriented company. The two technological trends have forced the company to rethink the exact value it needs and wants to provide to its customers in the face of increasing competition. It has faced a specific question of how to make the right strategic organisational and technological choices. On the organisational and marketing side, the company faced a challenge to transform the traditional direct sales model into a 'total solution team'. This entailed a shift in the nature of the sales representative's task. Instead of an individual sales representative-customer contact, a team-based approach was gradually introduced which increased the scope of services, such as providing document consultancy or taking over internal company document reproduction services. This transformation required the solution team to bring in knowledge on analysing and integrating hardware and software solutions in company's existing IT networks. The technological challenges of meeting the digitisation trend were related to the transformation from an analogue to digital product architecture, and the integration and creation of access to the right technologies. With an R&D department that was equipped to focus on the development of hardware, new capabilities had to be developed or accessed in order to make the digital transition. However, the increasing competitive pressure, the relatively small size compared to competitors, the choice of a unique copying and printing technology, raises the question of to what extent Océ is able and willing to use its suppliers' capabilities in this transition. Given the increasing pressure of competition to introduce cheaper, more functional, connectivity at an accelerating pace and with limited internal capacity, the question of 'how to use external expertise' has become more relevant for Océ.

4.3 Case study design and methodology

The first part of the empirical research is based on a *four-year research collaboration* with Océ. In contrast to the framework previously proposed by Wynstra (1998), which was based on three series of case studies in multiple industries, this case study was designed to enable a longitudinal case study within one company. This allowed us to study managerial actions regarding supplier involvement in-depth, both in a retrospective and real-time basis. A *longitudinal case study* within a high-tech sector provides a single setting with multiple observations over an extended period of time (Yin, 1994; Eisenhardt 1989). Such a research method fits well with our intention to study a phenomenon with a dynamic and process nature, and in which the unfolding events play an important role in building explanations. This sector was chosen for its known dependence on suppliers and its high intensity of technology. Very High Volume copiers meet the requirements for high-tech products as defined by De Ruiter and Lemmink (2001) in the sense that rapid developments take place in a highly technical environment, and that a relatively high level of technology-based uncertainty is associated with these products, both on the part of the manufacturer and the customer. Due to rapid digitisation of printers, copiers and communication technologies, product development and service development are becoming increasingly important and knowledge intensive.

We agreed with Océ that research would be carried out at the company's premises for two to three days per week, allowing the researcher to have access to the purchasing, manufacturing and R&D departments. This access enabled many events and discussions to be observed and overheard in a more natural setting instead of solely relying on pre-arranged interviews. I had a passive presence and unobtrusive so as not to interfere with on-going events and activities. The research was guided and supported by the creation of a cross-functional steering committee. This committee consisted of the vice-president of manufacturing, the vice-president of purchasing, the vice-president of R&D engineering and one of the R&D mechanical engineering managers. During this four year period, the steering committee held meetings every six months with the prime researcher and his supervisors, in order to discuss the set-up of the research, to report on the actual research process and to create access to relevant employees and documents within the organisation. In the meantime, individual members were contacted when necessary for more specific questions and discussions on particular case studies. Their involvement proved to be crucial in creating access and commitment within the organisation, in contact with suppliers and when reflecting on the case study findings. During the four year the position of vice-president of purchasing was fulfilled by three different persons. These changes did not directly affect the support for the research or results in a major way. The research at Océ was split into four phases:

(1) Exploratory interviews, documentation consultation and case study selection;
(2) Eight case studies of manufacturer and supplier collaboration in product development;
(3) Analysis;
(4) Definition of action research domain, design and execution.

We discuss the action research phase in Chapter 8. Suffice to say here that the first three phases, which we report on in this chapter and Chapter 5, have led to the definition of the action research plan.

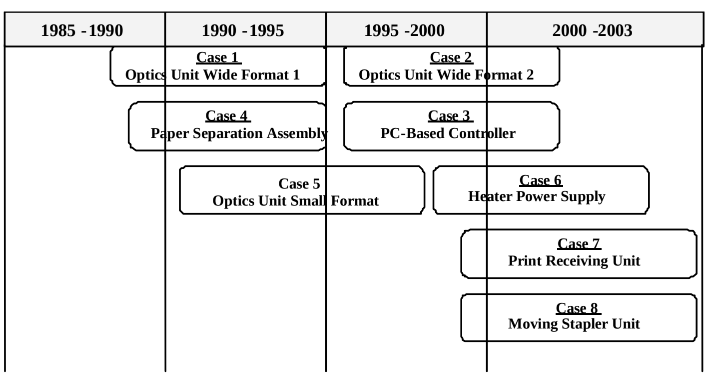
4.3.1 Exploratory research phase

The first phase was exploratory in nature, and was aimed at developing a general understanding of the internal organisation, the technical aspects of copiers and printers, and the process by which Océ develops them. An initial series of 21 exploratory interviews were carried out with managers and employees from different departments. These interviews are listed as general interviews in Appendix 4.1. Several internal documents were also consulted, and different meetings involving members from the R&D and purchasing department were attended. These meetings included departmental meetings involving senior purchasing employees, an introductory course for new R&D employees and a New Year meeting for all Océ Venlo employees.

4.3.2 Case study selection, sample and unit of analysis

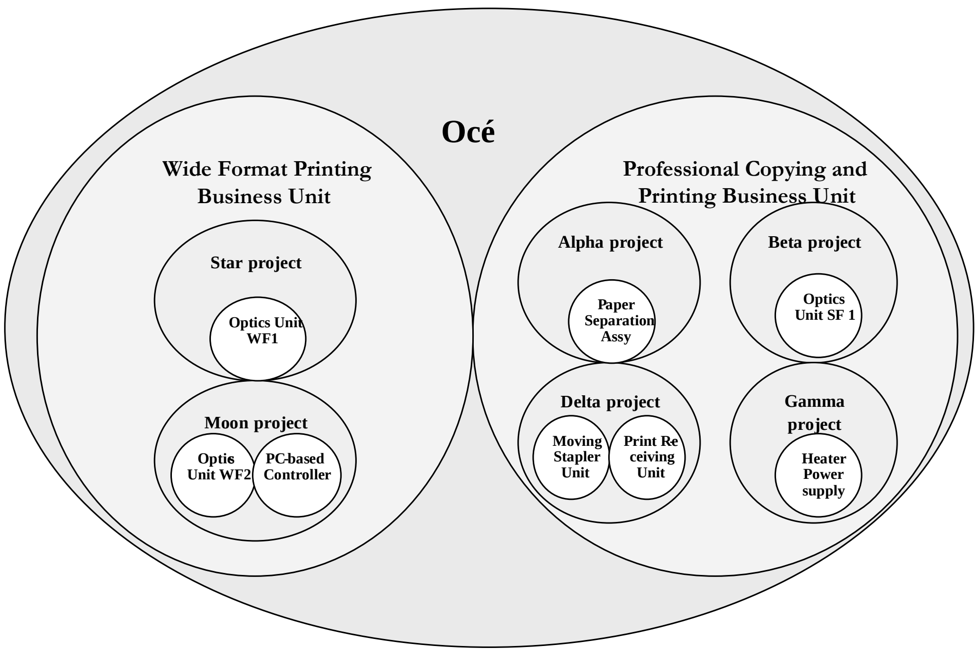
In the second phase, we conducted a series of case studies concerning eight collaborations between Océ and a single supplier in the context of a specific development (product/market) project. These collaborations involved six different suppliers and five different types of parts, and took place in the context of six different development projects. Two different business units had initiated these projects. Figure 4.2 gives an overview of the different parts and the timing (start/end) of the projects. All collaborations took place between 1989 and 2003.

Figure 4.2 Time-line for start and finish of case studies (based on overall project duration)



The case studies were selected in close consultation with managers from R&D, Manufacturing and Purchasing. Instead of random selection of cases we primarily used theoretical sampling as our selection approach (Yin, 1994) given the initial exploratory nature of the research. We decided to vary the cases in terms of the characteristics of the product development context. The factors largely followed from literature research (theoretical sampling), and to some extent were distilled from the initial interviews at the case study company. Figure 4.3 shows the links between the different organisational levels and contexts. By creating a controlled variation in the context of the collaborations, we expected to be able to develop specific hypotheses regarding the relationship between various product development contexts and the criticality of IPDS activities. We created a spread of contextual characteristics across three different levels of analysis: *business unit level, project level and part level.*

Figure 4.3 Cases and interconnections with parts, projects and business units



Selected Business Units

Since this is more than one business unit within Océ, we hoped to study collaborations with suppliers in a number of projects for each business unit. This would allow us to compare supplier involvement management practices between multiple business units. We started with the *Wide Format Printing Business Unit*, which develops, manufactures and sells printers that can print maximum E-size/A0, and serves engineering companies and departments, and construction and architectural companies. Océ is one of the top three players in the high and very high volume/speed printer niche market. However, in order to diversify its risk, they have sought new product/market combinations. Océ is increasingly active in developing wide format inkjet printers, which find their way to the publishing markets where products such as colour posters are increasingly in demand. The *Professional Copying and Printing Business Unit*[9] is

[9] The Business Unit has been recently integrated with the Production Printings Systems Business Unit and now form the Digital Document Systems Business Unit.

active in office printing, copying and reproduction services, mainly for professional users. In many market segments Océ is only a small player and is increasingly focusing on high volume and high-speed machines in combination with its job and application software and outsourcing services. In this volume and speed range, the market segments value productivity, as potential costs of machine downtime for the customer are substantial. In this segment Océ is therefore better positioned to sell its reliable and robust machines based on the total cost of ownership than in other segments.

Selected development projects

We selected five development projects from these two business units by varying the *degree of innovation of the development project* in which the cases are embedded. This criterion was used because the literature review pointed out that it is a potentially important factor that drives the need for specific activities to manage the involvement of suppliers. An overview of the projects and the degree of innovation is provided in Table 4.2.

Table 4.2 Innovation characteristics of selected development projects

Development Project	Star	Moon	Alpha	Beta	Gamma	Delta
Degree of Project innovation[10]	Medium-to-High	Medium	Low-Medium	Medium -high	Low-medium	Medium

Two projects belonging to the product portfolio within the Wide format Printing business unit were selected, namely, the 'Star' and the 'Moon' project. The Star project was a highly innovative project for Océ and the market. Its aim was to be the first digital wide format machine with a speed and print quality that was unprecedented within Oce and the markets it served. It consisted of a separate scanning station a print station onto which several print finishing operations could be attached. The *Moon* project was a project that was to ensure Océ's (digital) presence in the mid-volume segment, and would complement the portfolio of low and high-speed wide format machines. The machine was less innovative but had a higher degree of modularity and was the first digital machine for Océ in that segment. Since it considered the potential competition for this machine to be intense, particular emphasis was paid to develop a lower cost and modular approach.

Four development projects were selected from the Professional Copying and Printing business unit: the Alpha, Beta, Gamma and Delta projects. *Alpha* was one of the last analogue mid-volume office copiers to be introduced into the market by Océ. It aimed at building a reliable and productive machine that was easier to use than rival machines. The *Beta* project had to develop the first digital mid-high volume copier for the professional office environment. It was not aimed at modular innovation but rather on demanding copy quality targets. This prompted

[10] The 'degree of project innovation' was determined using the scores of the R&D project leader and the Manufacturing Project leader, who answered the following questions respectively on a five point scale: Newness of the final product's (1) components, (2) configuration, (3) product technologies and (4) manufacturing technologies.
We used the scores on their questions to determine the degree of project innovation: Low=1,2 Medium=3, High=4,5

a change from an analogue to a digital product architecture. During the project external market developments led management the decision to develop a digital copier that could be connected to a computer network, making it a digital printer. In the *Gamma* project a very high speed digital printing machine was to be developed that, due to time-to-market pressure, would produce only a limited number of innovations. The constraints to reuse parts of a previous digital architecture rendered it a low-to-moderately innovative product. The *Delta* project was concerned with the development of a high-speed printing machine targeted at professional users in the high volume market segments. The project can be considered to be a 'moderately innovative' project because it succeeded its analogue predecessor but it developed new, versatile paper finishing options such as stackers, receiving units etcetera and a new controller.

Selected Parts

In the context of these two business units and six development projects, we selected eight case studies concerning the development of six different types of parts. The eight case studies were selected following criteria derived from literature. We considered eight case studies as an appropriate number given our desire to examine both retrospective and real-life cases and to examine contrasting cases. More cases would increase the practical and research complexity; a lower number of cases would reduce the richness and variety on selected criteria. The parts varied in terms of technical complexity and perceived development risk. The variation in the degree of technical complexity[11] was based on the number of different product technologies and the degree to which a part determines the technical specifications and design of other parts. We therefore deliberately chose to select cases based on different types of technology categories: mechanical parts, mechatronic parts, electronics parts and opto-electronic parts. Although the parts often contain a combination of technologies, we wanted to understand whether the management of supplier involvement differs across these categories which have a clear core technology. We finally decided to use Océ's own risk assessment based on the position of the parts in their portfolio instrument (see Table 4.3). We asked the account buyer or the development engineer to indicate the initial portfolio code assessment. A code 1 and 3 reflect high technical or supply risks but differ in terms of the value of the buy–part[12]. A code 2 and 4 point to low-to-medium development and/or supply risk. Technical development risk could refer to close interaction, tight tolerances or lack of knowledge regarding certain technologies. Supply risk can stem from a lack of alternative suppliers, resulting in a limited willingness of the supplier to meet Océ's demands on technical and commercial aspects. Most of the parts in the selected case studies initially received a high-risk assessment, but some of them were expected to move towards lower risk levels. The two parts in the Delta project were special cases and gave us the opportunity to watch the collaboration unfold in real-time.

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[11] The number of components was not a good measure for complexity as suggested in Chapter 3, because it did not take the 'technical complexity' of designing and engineering into account.

[12] Océ has set its own arbitrary value threshold.

Table 4.3 Characteristics of selected parts

Parts	Optics Unit WF1	Optics Unit WF2	PC-based Controller	Paper Separation assembly	Optics Unit SF	Heater Power Supply	Print Receiving Unit	Moving Stapler Unit
Development complexity[13]	High	High	Medium	High	High	Medium	Medium	Medium
Degree to which part determines the technical specs and design of other parts	High	High	Medium	High	High	Medium	Low	Medium
Nature/nr of different techno-logies	Optics, Electronics Mechanics	Optics, Electronics Mechanics	Electronic s Mechanics	Mechanics Rubber	Optics, Electronics Mechanics	Electronic s Mechanics	Mechanics electronics SW	Mechanics, electronics, SW
Perceived risk/Port-folio code	High (Code 1)	Medium (Code 1)	Medium (Code 1)	Initially low (Code 4)	High (Code 2)	Initially High (Code 1)	Low/ medium (Code 2)	Low/ medium (Code 2)
Suppliers	Optico	Optico	Chain-PC	Astra	Optico	Cerel	Sorto	Motio

4.3.3 Data collection

The case studies took place by allowing the researcher to observe for a prolonged period of time, thus enabling him to observe interactions and processes in real-time. Semi-structured interviews were held for each case study, with representatives from multiple functions involved in a specific development project and with managers from several departments in the copier/printer company. In addition, supplier representatives were also consulted to obtain partial verification of case data and to better understand the problems encountered in the collaboration. In two cases, it was not possible to speak to the relevant persons at the supplier (Paper separation assembly, Heater power supply heater cases). We did not present any 'statements' from Océ representatives to the supplier during interviews. We emphasised the detection of events, issues and perspectives that could further help to understand the possible explanations for the outcome of the collaboration. In total 182 interviews were held, with an average of 19 interviews per case study. In some cases this number includes follow-up interviews with the same people. The initial set of interviewees was identified with the help of the steering committee. The need for additional interviews was determined in consultation with involved representatives from Purchasing, R&D and Manufacturing. We therefore followed a 'snowballing' approach. The largely retrospective cases were subject to the possible risk of interviewees not remembering all of the relevant details (Golden, 1992), oversimplifying and post-hoc attributions. We tried develop an insight into who had been involved in which aspect of the collaboration using both our framework as guidance but also to use additional open-ended questions. We cross-checked which objective historical events and steps have have taken place in interviews from different departments. We tried to distinguish between opinions and more 'objective' information from interviewees and other data sources (project reports).

[13] Development complexity is indicated as Low, Medium or High. It is determined by the number of different technologies and by the degree to which the part determines the specs and design of other parts. A part containing three different technologies is considered to be highly complex, while a part with two technologies is considered to be of medium complexity. A part that scored 4 or 5 is considered to be highly complex, 3 to be of medium complexity and 1,2 is of low complexity.

Taken together these steps allowed us achieve a more reliable and valid identification of causes and effects in the various collaborations.

Nevertheless, ideally real-time case studies are used to study processes (Pettigrew 1973; 1997; Pauwels, 2000) We paid special attention to the case study design and data collection for the two real-time case studies (Moving Stapler Unit and Print Receiving Unit cases). As the development activities were still ongoing, we were able to observe the collaboration as it unfolded; a large part of the history was still in the making. To build the real-time case study periodic updates (approximately every three months) were held with the representatives involved regarding the progress and the events that drive the collaboration. To some extent we also followed events after the collaboration with the supplier in the retrospective cases has finished (e.g. optics unit cases and the PC-based controller cases). This was critical to understand the observe possible changes in managing supplier involvement and associated learning effects. As an embedded researcher I have been a close observer, but tried to limit my influence on the collaboration or perceptions of people involved or to be a judge. Therefore, we did not choose participant observation as our datacollection methods for observing life interactions between buyer and supplier in the direct collaboration. However, we did complement interviews with other observations of life interactions in other internal meetings. The interviews lasted between 90 minutes and two hours. An overview of the interviewed persons and their functions is provided in Appendix 4.1.

The interview questions were semi-structured. The main questions were based on the elements of the adapted analytical framework developed in Chapter 3, in terms of the results, activities and conditions identified beforehand. These questions had an open character and were complemented by clarifying questions. In this way, we wanted to uncover the 'how', the 'who' and the 'when' of the management of collaborations. For the suppliers we adapted the Océ questionnaire in terms of how they have experienced the decision-making processes and to what extent they considered what were the main events and issues. The questions were asked in an order that would result in, as far as was possible, in a chronological account of the events in the collaboration. These questions were further complemented by questions regarding the performance of the overall development project. In order to detect other important events, which the questions related to the framework might fail to reveal, we asked open questions about the presence of other events and problems in this particular collaboration that had not yet been discussed in that interview. The semi-structured interview questions can be found in Appendix 4.2.

Most of the interviews were recorded, processed and sent back for verification by the interviewee, thereby increasing the validity of the case information (Yin, 1994). Some interviewees did not want the conversation to be taped, and so notes of these interviews were made and sent back for verification by the interviewee. A logbook that includes field notes was also kept as a way to follow different events that occurred in the Océ organisation. These notes enriched the case data and were used to verify some of the conclusions drawn in a particular case or to describe the contextual changes affecting that particular case. Examples of contextual changes include restructuring measures affecting the structure of the purchasing department, or the introduction of a new overall project phasing method, etc.

Information from multiple sources were compared and interpreted using the analytical framework for managing supplier involvement in product development (Wynstra, 1998). For the most extensive case studies (Optics Unit WF1, SF, MSU cases) the events were further verified and discussed in a workshop with relevant managers and project members from Manufacturing, Purchasing and R&D. This occurred on two different occasions (October 2001 and April 2003). The use of multiple information sources enabled the information to be validated regarding the same phenomenon by comparing and possibly discussing this information with different representatives (Yin, 1994). Moreover, it provided extra contextual information, which the involved persons may not have recalled independently.

4.3.4 Data analysis

A qualitative analysis method was adopted for this first series of case studies. We chose to start with a historical account of the collaboration in terms of the start of the development activities, followed by the preparation of the collaboration with the selected supplier. The execution of the collaboration is then described and finally the release of the part towards the end of the development project is analysed. If relevant, events are described that relate to that part after regular production had started. We have chosen to describe the cases by combining a chronological event-based account of the collaboration with views and opinions of the actors involved in the collaboration. After the historical account the main issues and problems observed during the collaboration were distilled and summarised. This approach does not yield result in a fully ethnographic and interpretative study, but provides sufficient richness in the dynamics and issues in managing the diverse set of collaborations. In Chapter 5, the Integrated Product Development and Sourcing framework (IPDS) subsequently serves as an instrument to further analyse how Océ has managed the involvement of suppliers in the development of these eights parts. We analyse how the patterns in the managerial activities and conditions can enrich our understanding which ones have been critical and contributing to the observed performance of the collaboration (short- and long-term collaboration results. The implications of the findings for reconceptualising the framework are discussed in Chapter 6.

4.4 Eight cases of supplier involvement in product development

The first three cases of manufacturer-supplier collaboration to be discussed take place within development projects belonging to the Wide Format Printing business unit. Each case study is described in terms of the historic set of events that characterise the start, the preparation of the collaboration, the actual development and the ramp-up of production, describing the issues during part release and later during regular delivery of the part. When specific statements from interviewees or from conversations are used, a reference between brackets is made to the specific function that the persons fulfilled.

4.4.1 Case 1: development of 'Optics Unit 1- Star project'

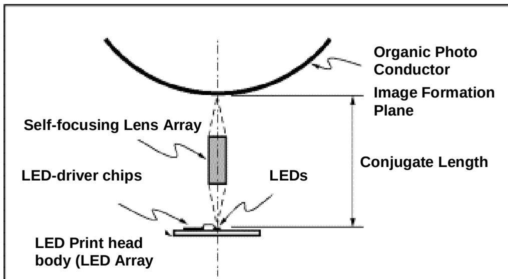


Figure 4.4 basic structure of LED Print Head

The optics unit enables a light projection of the latent image of the original text or image onto the Organic Photo Conductor. The unit applies Light Emitting Diodes (LEDs) as the core light projection technology in combination with a special Self Focusing Lens. The optics unit was developed in the Star project, which was aimed at developing the first digital printer for Océ to succeed the last generation of analogue wide format copiers. After several years of individual monitoring of technological developments in both markets, one development engineer started a more concrete consultation of potential suppliers of LED-print head technology. Since Océ did not yet have a lot of knowledge regarding the digital technology of the optics unit, the development engineer looked for a supplier that would be able and willing to develop and produce wide format optics units at a specific resolution that would be suitable for Océ's unique printing process. The preliminary functional specifications were sent to Asian suppliers and one US supplier. At the end of the 1980s, R&D selected a US supplier as their development partner. The lower confidence in their technological capabilities and the cost price estimations ruled out the Asian offers at that time. The US supplier would develop the technology and Océ would receive the products and know-how. Although the supplier initially appeared to be motivated to start the co-development because of a credible prospect for production and the presence of a clear development contract, the collaboration was terminated after two years on the initiative of the supplier. It had lost an important customer for this type of optics application, and it no longer considered it viable to continue. The main reason for Océ to agree to the discontinuation was the higher cost price compared to the initial estimate (ref: Océ development engineer). The end result of the collaboration with the US supplier was a working laboratory model and a great deal of knowledge in terms of problem framing, cooling techniques and an awareness of interfaces in this technology in an Océ-specific printing technology context (ref: Océ development engineer). However, the Star project ran large functional and planning risks. The back-up contacts that had been maintained with other suppliers (although at a low-level), in particular with Optico, were therefore made use of. The commercial aspects of the optics init were to be handled by a new buyer within the 'Specials commodity group'. At that time, the Manufacturing and Logistics department had only limited input to the supplier selection activity. A pragmatic instead of a thorough and formal assessment of the supplier's organisation and capabilities took place. The choice for

Optico was an 'all or nothing' choice. Without this supplier there would have been no project (ref. Océ account buyer; Océ development engineer). During the collaboration with the US supplier, Optico had already sent a prototype to the Océ Development engineer, but the quality was insufficient. From a technical point of view Optico had the most promising prototypes and the cost price estimation was very attractive with the cost price of the US supplier in mind. However, the choice was primarily driven by Optico being the only supplier willing to collaborate with Océ in developing a customer-specific LED print head technology (LPH). Optico's LED division was part of a large conglomerate, and one of its business units produced LPHs for Asian manufacturers of small low volume printers and faxes. Although Optico did not initially consider the LPH technology to be new, some novel elements for the supplier were the customer-specific application of the technology in Océ's unique printing technology, the length of the print head, and the stringent specifications (ref: Optico senior engineer; Océ development engineer). The collaboration started without a development contract. Part of the development costs were incorporated into the prototype prices. This meant that they did not use a detailed planning but worked using six-monthly prototype cycles. During these cycles Océ encountered different technical, commercial and communication problems. The initial idea was to write down the functional specifications in addition to some critical design constraints, signalling the desire for a large supplier input and design responsibility. Océ was disappointed when it noticed that the actual supplier input and design responsibility was lower than expected. The supplier prototypes were judged to be of insufficient quality and follow-up prototype cycles revealed shortcomings concerning some electronics, mechanical and optical design aspects. As a result, several development tasks (electronics and mechanical design) were in-sourced, including the responsibility for developing protocols for fine-tuning and testing the complete optics unit (print head body and the lens). This in-sourcing move caused some discussion between the R&D, purchasing and manufacturing groups within the Manufacturing and Logistics department (M&L), the latter favouring as much standardisation as possible. However, the development engineer convinced the groups that Optico would not be able to further develop a reliable optics unit based on a purely standard product, given the demanding Océ quality performance targets and the reversed application of the supplier's product. The production of LEDs and the insertion of drivers and LEDs on the substrate was a core activity, which remained under Optico's flag. During the development, Océ's relationship with the second tier supplier of the lens (SLA) and the quality assurance of the lenses became critical for achieving the quality targets. This supplier was a sole source and supplied a component that had a large impact on the final print quality. One of the core technical development problems was the continuing mismatch in functional behaviour and the technical specifications that should ensure the correct functional behaviour. Several R&D engineers argued that, in hindsight, Océ was also not fully capable of coming up with appropriate specifications. The mechanical engineer stated, 'Optico possessed a good type of LPH for use in conjunction with blackwriting printing principles. However, one has to start all over again because of the reversed application in the Océ printer and stringent performance demands'. According to the electronics engineer Océ expected too much. The development was therefore, certainly in combination with defining adequate test and assembly procedures, to a large extent characterised by trial and error. The Star project team, and the R&D engineers and the manufacturing organisation in particular, had to put a great deal of effort into realising the release of the optics unit and preparing for a smooth assembly ramp-up. The mechanical engineer stated, 'the official release of the optics unit was a big happening involving a lot of cross-functional communication'. During and after the release phase it appeared that the consistency in the quality of the optics unit could not be guaranteed. The Project Progress Report reported that, *'We have not been able to define the specifications for the print head bodies from Optico in such a way that they suit both our assembly and Optico's production process'.* The delivery resulted in a significant amount of rejects and rework for Océ at the supplier, at Océ's manufacturing operations (ref: manufacturing quality engineer) and in the field (Océ Service). However, it we should note that the overall project was introduced successfully and those optics units that worked were perceived by the customer as offering a significant quality improvement. In addition to technical development problems, Océ faced a challenge to reduce the cost price risk; this was not given the same priority. The former purchasing electronics manager (ref: workshop) observed that during meetings with Optico cost price discussions were usually held at the end of the meeting under time pressure. This certainly did not help effective communication. A more important risk to be managed was the assurance of supply continuity, especially during production ramp-up. Optico was practically the only supplier that could deliver these optics units, and it was located far away from Océ's manufacturing base. Switching was not a real option. In combination with the initial quality problems and the difficulties the supplier's difficulties in scaling up the optics unit production, this situation led to more management involvement on both sides to deal with the delivery and quality problems. Besides visiting Optico, they decided to invest in additional safety stock, despite the high inventory-keeping costs and a risk of this stock becoming obsolete when crucial design changes had to be implemented.

A final problem concerned the communication between the engineers of the two companies. Communication was difficult due to the language barrier in combination with the absolute and cultural distance between Océ and Optico. This restricted frequent face-to-face communication. In addition, it was not possible to digitally exchange CAD files. This was difficult for those involved, but was not the cause of any delay (ref: Star R&D project leader). After some time, an Asian intermediary was brought into the project, providing translating and co-ordination services; several years later an Océ Purchasing representative was stationed in the Far East, resulting in closer communication lines.

4.4.2 CASE 2: development of 'Optics Unit WF2 – Moon project'

The second case concerned the development of a wide format optics unit (WF2) for a mid-volume wide format printer. The development of this optics unit differed from the related wide format optics unit development in the Star project in terms of the specific optics concept chosen for this wide format unit. The concept was steered by the overall project's technology choice to use a commonly applied printing process concept, given the cost-price target of the project. The project's target was to advance to a higher resolution wide format optics unit based on a standardly available supplier product based on LED print head technology. Since the Moon project was explicitly subject to a strong internal time-to-market pressure, the project team chose not to develop a new optics unit in-house. Therefore, in cooperation with the purchasing department, it subsequently approached the optics unit supplier market with functional specifications. Only Optico and one other supplier replied. The reasons for choosing Optico as the final supplier were based on cost price considerations and the strategic relationship that had been built up through the Star and Beta projects. Optico got involved in the mid-1990s by sending the first prototypes. Océ did not put dedicated (development) engineers on the optics unit development. One person within the project and two engineers from other projects spent time on several prototype cycles. Functional Management in R&D considered this to be appropriate, based on the technical risk and budget considerations. Optico had still not increased its engineering capacity since their involvement in the optics unit development for the Star project and other projects. This caused some concern within Océ. Optico would ultimately deliver the lens and the print head together as the optics unit to Océ. The prototypes provided by Optico were based on an existing design developed for another customer. From a technical perspective, this initially gave the project the confidence that the risks were acceptable. From a financial perspective the cost price was also relatively certain, since Optico had already been carried out the development. However, after analysing the prototypes some unexpected technical shortcomings were noticed. In this project the supplier's electronics and mechanical design capabilities once again did not match Océ's expectations. Océ took the initiative to carry out the two major redesign activities. Distance and communication barriers were seen as high risks in meeting the deadline. As the Océ engineer from the Beta project had pressing issues to discuss for that project, he could not always pay full attention to the issues in the Moon project. The account buyer also evaluated and communicated some technical aspects regarding the mechanical design. Although the mechanical redesign occurred relatively late (during the machine release phase), the optics unit development was never on the critical path. The rejection rates of the optics unit during regular production were acceptable, except for some problems with missing LEDs and foreign particles originating from Optico's assembly process.

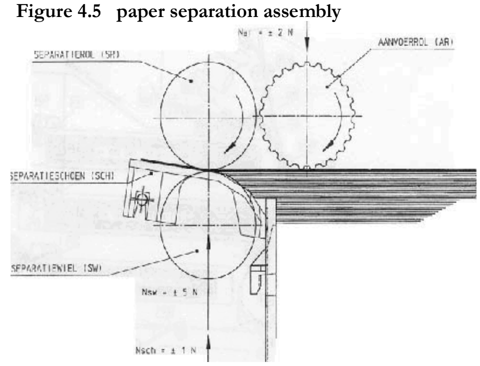
4.2.3 CASE 3: development of PC-based controller – Moon project

The third case concerns the development of a controller, in fact the controller hardware in the same Moon project as discussed in the previous case study. The controller is a device that controls the data traffic and translation required for the several elements of a scanner and printer configuration. The controller hardware is one of the crucial parts needed for image processing and handling of the print jobs. The development of the controller first required the hardware and software standards to be chosen for the given project targets. During the project a switch was made from a dedicated controller environment to a standard PC-based controller architecture, for various cost, functionality and marketing reasons. The development effort was gradually turned into a platform project that would be able to serve other projects as well, but with the Moon project as its first internal client. After the platform choice, some time was spent on supplier market research, carried out by both Purchasing and R&D team members. Although, several PC-suppliers were evaluated based on criteria such as price and ease of information transfer between Océ and the supplier, the supplier selection process was only transparent with regards the technical aspects. It is hard to establish (Océ electronics engineer) what the decisive criterion were to choose this supplier. Halfway through the project, the project team needed to select a new supplier, following quality problems and the financial situation of the initially chosen supplier. In the selection process of the first supplier, one of the Océ executive board members was involved in addition to R&D and Purchasing Management. In this later selection of the supplier, one of the sales companies influenced the decision. Important selection criteria were the price, the ability to provide customised parts, and the setting up of a specific OEM support team. The new supplier was a large PC manufacturer (ChainPC), who wanted to develop alternative markets in addition to its traditional, strong mass consumer PC market. One of the supplier's national sales companies started to develop the first contacts with Océ. The supplier indicated that Océ was a pioneering customer, in the sense that they were not used to selling PC's that become part of the customer's final product. They therefore created a new business group to serve OEM customers in Europe, and adopted a specific configuration and delivery team approach that would help to deal with customer- specific questions. The development process was characterised by incorporating a majority of standard PC-components. Océ decided to design a limited number of specific components itself, because solutions on the supplier market at that time appeared to be very costly. ChainPC was surprised by the way Océ specified the PC, and tried to make changes to standard specifications. For example, Océ requested that the supplier brand labels on the PCs were replaced by their own name. This last request necessitated even high-level lobbying by Océ for approval by the CEO of ChainPC. These requests were driven by demands from different internal Océ departments. The customisation discussions went further than ChainPC had ever experienced. The vice-president of R&D systems confirmed the problem of developing an organisational interface in which the supplier would be able to deal with customer-specific requests. According to the second account buyer, '*Océ had insufficiently realised what the implications of working with a strong specialist partner in a development project would be. Océ assumed it chose a standard PC, but then requested adaptations to achieve its requirements. It initially overrelied on the supplier's willingness and ability to change its organisation, while we did not communicate this internally and with the supplier*'. It was clearly a learning process (ref: electronics engineer). Océ manufacturing project representatives initially expected to work according to a model of 'moving supplier boxes' with few assembly activities performed by Océ. However, this assembly strategy was gradually reconsidered during production start up and regular production; Océ was now increasingly performing specific testing and assembly activities internally. The co-ordination and communication between Océ and ChainPC's dispersed commercial, production and R&D locations became an issue. Not all locations were quickly and easily accessible when information or approvals were necessary. ChainPC itself also had difficulties in mobilising the internal development and production groups to respond to Océ's specific requests. This was because ChainPC's engineers were puzzled by the Océ engineers' questions. One of the development engineers indicated that besides the synchronisation of internal controller hardware and software development, the project team faced an additional challenge. Supplier-driven dynamics, related to the obsolescence of PC components and the fast pace introduction of next generation PC models, required a time-consuming co-ordination effort to validate the new components in the overall systems architecture during development. It was especially during production start up and the period after that in which specific assembly and quality problems were reported that disrupted Océ's assembly process. All PC components indeed became obsolete much faster than expected, necessitating continuous testing and validation efforts by the Océ R&D team. In addition, ChainPC introduced a next generation PC before Océ's product was properly introduced on the market, thus yielding functional problems. Certain components in a PC affected the ability to have a reliable real-time interaction between the scanner, printer and controller (preventing a data loss or machine breakdown). New hardware introductions also affected a number of Océ machines in terms of malfunctioning of application software (ref: Océ manufacturing engineer).

Unexpectedly, the industry norms attached to standard PCs did not automatically result in compliance with Environmental and Safety norms applying to the copier and printer markets where Océ operated. The first year of production was characterised by a number of rejections due to non-conformance to specifications, and later on regarding the durability and component obsoleteness issues. Furthermore, safety stocks had to be held because the Océ R&D organisation was unable to keep up with the release of new validated components. Field problems and costs were also reported. The account buyer mentioned that discussions on liability and warranty were lengthy, also because two business units had chosen different supplier warranty policies (ref: account buyer 2, ChainPC account manager). After market introduction, various inter-company teams at different organisational levels were gradually formed to deal with the operational, product development and relationship issues. One of the critical actions to reduce the workload for Océ on testing, and to accommodate changes in assembly and service operations, was to change the format in which Océ specified PCs. This had led to communication problems with the supplier's commercial and production sites. Secondly, the supplier considered the parts to be over-specified giving Océ no room for manoeuvre (ref: ChainPC account manager). In the period after the Moon project was introduced onto the market, attempts were therefore made to seek more structural improvements. These measures were related to improving the specification process, reducing the variety of critical components, developing an extended controller platform similar to those for multiple projects and setting up a testing facility at ChainPC.

4.4.4 CASE 4: development of 'paper separation assembly - Alpha project'

Figure 4.5 paper separation assembly



This case study concerns the development of a paper separation assembly taking place in the Alpha project. The separation assembly separates two sheets of paper that are transported from the paper input unit into the machine. It consists of three rubber rolls, each roll containing a plastic core in which a bearing is assembled. Finally, a machined shaft is pressed into the bearing. The separation assembly is a critical function due to its major interaction with the paper and the machine itself. Each role must have a different coefficient of friction in relation to each other roll and in relation to the paper sheets that are drawn into the machine. As simple as a rubber roll may seem, product design and development is complex due to the large number of variables in the design, including rubber and plastics composition which have different properties in combinations with different sizes and types of paper. Moreover, it is considered to be an engineering challenge to combine individual tolerances achieving a satisfactory overall tolerance.

The paper separation function was an existing function and the R&D project team had decided to use the existing solution from a previous copier. However, during the initial development phases of the Alpha project relatively little attention had been given to the separation function, because R&D usually focused first on the core copying process (ref: mechanical engineer). During the engineering phase the existing separation rolls were used in machine tests. Several technical problems occurred during machine tests when using different types of paper. The engineer explained that market developments spurred the availability and use of different sizes of paper and of glossy paper, which could not be handled by the existing rubber rolls. R&D now had to start up extra development activities because the late discovery made the development more risky than expected. R&D tackled this unforeseen problem by internally investigating new rubber compounds for the upper roll. They decided to do this in-house, because, at that time, Océ did not know any suppliers who had the design-specific knowledge of separating paper. The market seemed to be too small for a supplier to survive with a specialisation in development activities. Solutions of competitors were also not considered to be satisfactory. According to the Océ engineer this solution path was sub-optimising the function, but time pressure was too high to consider any other option. The development process of the compound was therefore based on trial and error, where a large chemical company supplied the requested batches of raw materials but did not actively provide design input. It appeared that the raw material specifications and tolerance setting were very difficult activities. After many tests a compound was found based on a secret recipe. Now a supplier had to be selected to produce the rubber rolls and to assemble them. At the end of the engineering phase the supplier selection process was started. The request for quotation was sent to two current suppliers, and was part of a larger quotation package of other rubber components used in multiple projects. According to the account buyer, the choice for supplier 'Astra' was made because of their relative experience in the manufacturing of the specific size and type of material used for the separation roll, the short communication lines and lower transportation costs. The supplier's input in the engineering process was very limited. It provided feedback on manufacturability aspects of the plastic core and the assembly. No major problems were anticipated during the project. Since the recipe of the rubber compound was still secret at that time, Océ arranged to mix the ingredients and supply the compound to Astra. The supplier would then mould the rolls and insert a bearing and plastic core inside them. During the years following market introduction, several quality problems occurred that caused machine interruptions. Moreover, many assemblies required a lot of service to replace the rolls. One of the suspected contributors to the drop in quality was the transfer of production facilities to a location in Eastern Europe. According to the second account buyer, the durability of the rolls was reduced and Astra's turnover increased visibly. Océ felt that Astra had informed them late of the high risks that were associated with this type of moulding product. Océ judged that it was in a captive buyer situation, switching being hardly possible. Therefore, Océ Purchasing, Manufacturing and R&D and Astra had to exert a significant amount of effort to find a way to improve the quality performance.

4.4.4 CASE 5: development of Optics Unit SF (Small Format) – Beta Project

The optics unit in the Beta project provided the same functionality as the two optics units in the Star and Moon projects. However, Océ's first mid-to-high volume digital copier for the professional office environment required a significantly smaller format. Again the optics unit was a critical contributor in achieving an unprecedented combination of copy quality and speed performance. A year after the Star project started the optics unit development, the Beta R&D project team identified two candidate optical technologies and started two parallel development paths, given the high technical feasibility risk. One group further examined the opportunities and limitations of Laser Scan Technology (LST) and the other group further investigated LPH technology. Collaboration with suppliers in LS-technology was sought on both module and component level. Since Océ already bought an LS Module for another project, it seemed worthwhile to explore this path. The LPH technology was not as mature as LS-technology, however, it had some promising developments towards higher resolutions. During this phase, R&D contacted the purchasing department suggesting potential suppliers and to establish contacts with these suppliers. After evaluation of the results from both technology development groups, the R&D Technical Committee concluded that the target performance specifications were soon expected to soon hit the technical limits of the LS technology and that the LPH technology therefore had the best prospects of achieving the quality targets and contributing to meeting Beta's cost price target. This decision was taken at the autonomous project level. However, the functional management from several levels were consulted and approached for resource support. This informal process preceded the final approval. After a supplier market research study consisting of a written request followed up by a visit by one buyer and an engineer in Asia, only Optico was considered to be attractive and willing to start developing a customer-specific optics unit. Other suppliers could not be motivated to work with Océ on the customer-specific development terms and the expected sales.

The collaboration with Optico started without a development contract and used a rough planning without detailed intermediate milestones and required activities. The purchasing department got actively involved in the project in early 1990s and was spokesperson for commercial aspects in the development relationship with Optico. Contacts at management level were established by a formal visit from the R&D director at a time when the Star project wanted to further the collaboration with Optico. Optico had the same two people working in the Star project available for development activities. Initially the R&D representatives thought for that the technical development tasks could be divided using a sort of 'black box development' based on the existing supplier prototype. Optico would send a standard optics unit based on functional specifications, and Océ would allow the supplier to have a large design input and responsibility. However, in a similar way as with the optics unit development in the Star project, the engineers noticed an unsatisfactory quality level in the first prototype(s). Océ received wrongly-sized optics units, and considered the power supply concept to be unsatisfactory. After the first prototype delivery, R&D and Purchasing therefore started to discuss changing the development responsibility assigned to Optico. From that moment onwards, six-to-eight month prototype evaluation cycles were initiated. Océ evaluated prototypes and planned design changes, they fed back these new design changes and waited for Optico to implement them. The Océ optics unit development team was surprised by the amount of redesign that had to be carried out on the electrical circuit, mechanical construction and other optical-mechanical aspects. The engineers again encountered major difficulties in translating relationships between light output, lens quality and copy quality into technical specifications, including testing and fine-tuning procedures. Océ therefore carried out some of the design and engineering activities itself. As in the Star project, the relationship with the second tier lens supplier required a lot of attention, this time because a lot of expensive lenses were rejected. In contrast to the Star project, Océ decided that Optico should remain responsible for assembling and fine-tuning the lens onto the print head. As a result the development team devoted significantly more attention to the development than was originally planned. The project team also faced a difficult decision to incorporate an electronics redesign before or after the first market introduction. In the project progress report, the project team described the status of the optics unit at the start of the release phase, *"We are still in the phase of understanding how things are working. We are not yet ready for 'engineering'"*. Since the development project had decided to use a multi-product release strategy, the optics unit engineers carried out the most critical redesign activities, leaving other aspects for release two of the digital copier. Close to market introduction, Océ manufacturing representatives also had to undertake large efforts to release the print head and prepare for smooth assembly. The Beta project start-up experienced great problems in rejected optics units, and some problems regarding copy quality. Since the market introduction of the Beta project had already been delayed due to software-development problems, time-to-market had become the top priority. In order to reduce the delivery risk a lot of optics units were therefore kept in stock. These measures, in combination with the sorting and testing activities and rejection rates, resulted in high costs for Océ. Ultimately, the copy quality of the Beta copier was well received in the market. The true cause of the below target copy quality was not known for a very long time. Some of the rejects can be attributed to Optico's assembly and fine-tuning activities, and some to the quality of the produced lenses. However, it later appeared that some of the rejected optics units were not tested with reliable testing procedures at Océ. This only became clear several years after market introduction, during a special investigation.

4.4.5 CASE 6: Development of Heater Power Supply –Gamma project

The power supply in this case study is an electronics component able to control the power in various steps needed for a paper heating function. The paper heater warms up the sheets of paper before the toner is fused onto the paper. A power supply has to provide power according to the needs of a specific function, while complying with international directives. The development of this particular power supply was preceded by a project-independent discussion regarding the impact of new European directives for harmonics and flickering levels on Océ copiers and printers and possible non-compliance risks. The harmonics norm regulates the degree to which products are allowed to pollute the main voltage on the public electricity network caused by the deviation from a sinus shaped current usage. The flickering norm refers to how much a machine is allowed to react to a fluctuation in the mains voltage. In general, the development of power supplies is influenced by the supply market itself and the norms (or changes in the norms) set by international regulatory bodies. Océ therefore decided to become a member of a working group that prepared and discussed changes in directives at a European level. The group’s regulations are captured in so-called "SENELEC directives". During the mid-1990s the Océ representative rang the alarm bells because of the introduction of new harmonics and flickering directives; these would be obligatory several years later when market introductions of several projects were planned. The norm change was proposed and stimulated by the major public utility companies, who were also members of the working group. The Océ representative informed R&D and Purchasing, after which a special task group was formed to analyse the impact of these directives on Océ copiers and printers. It concluded that power supplies in several projects would not be able to comply with the new directives. It was particularly the power supplies for functions requiring a lot of power, such as heaters and certain optics units, that would need a different solution. This solution could not be developed internally due to the scarce resources and original tight project planning (R&D engineer). However, according to the R&D electronics engineering manager it was also policy to have power supplies largely developed with current partners. Therefore, three well-known suppliers were invited to brainstorm on the problem and present their solutions to tackle this problem before the actual development of the power supply took place in the Gamma project. The goal was to have a solution available as soon as the standard was introduced and obligatory. According to the engineer, 'the priorities in meeting the various development targets were clear: developing a solution for the problem and a reliable power supply. This solution was allowed to cost something' (ref: electronics engineer). After these presentations, the directives crystallised and led Océ to activate a strategy to delay the acceptation process of the directives. The Océ R&D director visited a number of major multinational manufacturers that used power supplies extensively and would be seriously affected by this norm. These companies were not members of this particular norm committee. The effect of this roundtrip was a mobilisation of resistance and the creation of a critical mass against the standard.

Two suppliers presented a solution to Océ that still had several disadvantages. One of them was the negative cost-price consequence for all machines, although Océ did not know whether all machines needed this adaptation in order to comply with the norm. A second solution presented by Cerel was considered much better and used a simple concept, providing an innovative and machine-independent solution. The advantage of this innovation was that Océ did not have to adapt its existing machines. Not all of the projects had to choose this solution, as the gap in the directives also made other, software-based solutions possible. For the heater power supply in the Gamma project, Cerel offered the most attractive concept, which represented a machine-independent solution. Purchasing and R&D selected Cerel on time in the development phase of the overall project planning (ref: account buyer and R&D electronics engineer). The concept still had to be proven and that is why it was considered to be a high risk and high value item requiring early attention in the development process. Cerel had about twenty percent of its engineering and laboratory workforce working on power supplies for Océ. In this case study one engineer on each side carried out most of the development work. The concept proposed by Cerel was further improved based on a suggestion by the Océ engineer involved, now meeting life cycle targets for the heater tube. In about sixteen weeks a number of prototypes were made, followed by Océ in-house tests. After the feasibility of the concept had been proven for the specific heater function, further development and design refinements were carried out. Specific changes regarding the geometry had to be carried out in three prototype cycles[14]. This was the most important development aspect that could not be solved in one prototype cycle, also because some of the heater interfaces had changed. During the release phase of the Gamma project an additional assembly task was transferred to Cerel. This involved some metal assembly interfacing with the power supply. The outsourcing of assembly responsibility was stimulated by the 'Higher Level Systems Buying' initiative within the purchasing organisation. During the part release phase of the Gamma project, two additional changes occurred in the design. One change came unannounced by Cerel. Since they had reduced the size of some components, the geometric fit

[14] For example, the location of the incoming and outgoing current, position of certain components and height of cooling profile.

in the machine was no longer correct. After some relaying of bundles and some geometrical changes, the new prototype fitted into the machine. The second change was initiated at the end of 2000 by Océ who asked for additional control output error detection for servicing purposes. This change did not cause any delays or functional problems. However, one problem arose late in the overall project just after market introduction. A new European safety norm, demanding copiers and printers to be able to handle extreme peaks on the electricity net, could not be met. According to the Océ electronics engineer this had been an underestimation by the project team. However, Cerel stepped in extremely fast and was able to find a solution and quickly ramp-up production. Despite this last change, the concept was proven and the directives/standards were met. The specifications were relatively stable and the product performed well and could be produced on time. An additional advantage was the contract in which it was agreed that Océ could use this power supply concept in all its machines, even if it decides to source the power supply elsewhere. The supplier was also satisfied with the spin-offs of this particular collaboration, as it filed for a patent for the concept developed. Given the nature of the regulatory risk and the overall project priorities, the cost price and development costs were not such big issues at that time and received limited attention (ref: Océ account buyer and electronics engineer). Several years later Cerel was acquired by one of its main competitors and, as such, created an enormous amount of uncertainty on both sides as to the strategic direction of Cerel and its ability to continue its collaboration with Océ.

4.4.6 CASE 7: Development Print Receiving Unit –Delta project

The Print Receiving Unit (hereafter called PRU) is a functional module part of a larger finishing system. A finishing system is the section of the copier/printer through which the copy or print is transported and where stapling, sorting or other operations on a document set occurs. The PRU consists of a tower of four dynamically moving sets of trays on which sets of prints are collected and offered to the user. Important customer interaction aspects are safety and the user-interface. The PRU was identified in the Delta project, which had been specifically targeted for increased supplier involvement regarding the product and production engineering of certain modules. A large motivator was the lack of 'internal engineering capacity'. Attempts were made to find several clusters of suppliers that were capable of engineering and producing different modules in the Delta project and other projects. The first supplier to be involved in developing (not producing) the PRU was an engineering company selected by the R&D-department. This collaboration was discontinued after the effort did not result in a properly functioning and manufacturable prototype. After comparing several possible candidates, R&D and Purchasing Management selected Sorto as the new supplier. Sorto was a business unit that carried out engineering and

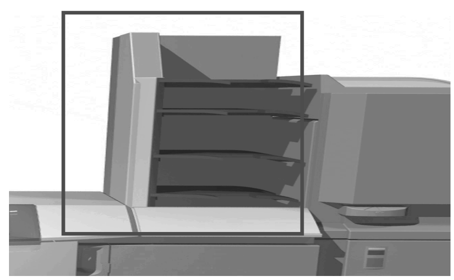


Figure 4.6 Print Receiving Unit

assembly services of modules for some customers in the telecommunication and printer industry, on a limited scale. Given its possession of internal facilities for the production of plastics and metal parts Sorto was considered to be a promising supplier. For Océ, the PRU concept was an existing functional module that underwent a complete redesign. For the supplier, the type of module was new but the paper handling application was familiar. Océ expected the supplier to further improve Océ's prototype, which it had continued to develop internally after the initial collaboration had failed. The supplier's input to the development of this unit was mainly expected in the area of engineering for production and delivery of partially pre-tested prototypes. Although the start up with the Delta Engineers did not result in the desired engineering advances, the assignment of a new engineer on the Océ side marked the start of a fast improvement of the design and in catching up with the project planning. A two-stage engineering project plan was written in which an analysis and an execution phase were mutually agreed.

It was Sorto that mainly pointed to a potential design and reliability problem. After internal testing, an increased workload was assigned to the supplier, combined with a direct and close cooperation with the new Océ engineer. Whereas the engineering collaboration was first characterised by an emphasis on drawing the PRU and its parts and meeting official engineering quality milestones, this approach changed when the new Océ engineer was introduced. A more hands-on approach gradually emerged, based on fast iterative prototype development cycles. This represented a deviation from the usual Océ procedures and sparked some internal discussions in the Engineering department as to whether this was desirable. Progress was significant, however, and the simplified design appealed to many representatives within Océ and provided the prospect of reduced costs compared to the original R&D target. However, Océ's manufacturing department started a discussion at both project and management level regarding the appropriateness of the tight tolerances proposed by the supplier and in general regarding production assembly capabilities (ref: vice-president of manufacturing; manufacturing project leader). This was partially fuelled by a less successful collaboration concerning a similar unit in another project. At the end of the engineering collaboration a new account buyer entered the collaboration. He suggested that the manufacturing representatives visit the supplier's plant. This turned their initial doubts into a positive impression of the supplier's capabilities. The collaboration was characterised by multiple discussion and negotiation rounds relatively late in the project, concerning the exact cost price model and the specific overhead percentages to be used. The R&D cost estimate was met. However, no clear, full cost target had been set in advance taking into account the total costs (overhead and transportation costs and the supplier's profit margin). During the collaboration the continuity of the relationship had been at stake. This has been fuelled by various developments and sentiments on both sides. First, Sorto's plant management announced that it had to stop producing plastic parts, and secondly the corporate board decided that Sorto would be divested. This change in ownership structure caused some doubts in various departments within the Océ organisation. Furthermore, due to the premature termination of the collaboration in another project, doubts were lingering as to whether to continue with this particular supplier in the Delta project. Although the engineering collaboration was perceived as successful, some interviewees questioned how valuable the collaboration would be if Sorto's main engineer, who had contributed the most during the product and production engineering phases, were to leave. Everybody agreed that this situation constituted a serious risk and this was therefore communicated to Sorto. From Sorto's perspective, the various project delays with which Océ confronted them were an undesirable aspect of the collaboration. In addition, Sorto's trust in the collaboration with Océ was severely put to the test when the collaboration and production responsibility was cancelled in the other project. All in all, the collaboration was characterised by both an increased and decreased contribution to the PRU design, a changing team composition on both sides, and prolonged discussions regarding cost price and assigning production responsibility. At market introduction, Sorto was chosen to produce the unit, thus allowing them to gain experience and to disprove Océ's doubts. The industrialisation of the unit was successful according to the latest project planning of Océ.

4.4.7 CASE 8: Development of Moving Stapler Unit – Delta project

This case study involves a Moving Stapler Unit (hereafter called MSU). It is a module that is part of a larger finishing system of a high-volume digital copier/printer for central reprographic environments. The MSU staples sheets of paper with high precision and speed, using two moving stapler heads. The MSU development became part of a regional supplier/technology clustering initiative that was strongly supported by the national government. The joint objective was to develop competent networks of suppliers in the country. The Océ representative responsible for setting up the supplier clustering initiative therefore consulted a number of development project teams on possible candidate modules. The Delta development project team identified the MSU as one of the possible candidates for external collaboration during development and engineering. Representatives from both the purchasing and R&D departments were involved in the selection process. After briefly considering a limited number of potential suppliers, talks were intensified with Motio. Motio was a supplier presenting itself as a development, engineering and production partner with specific development and engineering competences related to mechatronics and specifically to positioning moving parts. Although some informal contacts between Motio and R&D already existed, they had not yet resulted in a concrete collaboration in a development project. The decision to opt for Motio followed after a limited number of meetings at both companies, in which the vice president of R&D engineering, the vice-president of purchasing and to some extent the vice president of manufacturing tried to verify what their true 'motion control' competence consisted of. Ultimately, Motio was selected for the engineering collaboration, and the intention was to grant them the assembly responsibility. Both parties labelled the project as a serious pilot project. The intention was to find other projects if this project was successful. Motio would act as the leading supplier under the flag of the clustering initiative. The start of the collaboration occurred during the early development phase of the Delta project. For Océ a moving stapler head was a new concept compared to the single staplers in their previously developed copiers. The stapling application was new for Motio, but the underlying technologies, working together on controlling the motion of several components in a machine, were not (ref: Motio account manager, project manager). Based on a preliminary laboratory model developed by Océ, both Océ's engineer and buyer stated that the idea was to approach the MSU largely as a black box development, implying a transfer of responsibility of engineering tasks and the development of technical specifications to Motio. A first official engineering project plan was written by Motio two years after the initial acquisition contacts; it described the technical, planning, and cost-related targets. Engineering budgets were defined including deliverables in the several engineering disciplines. A formal engineering contract was also signed and a communication structure was agreed upon at project and management level, ensuring that representatives from disciplines on both sides could discuss the relevant issues. Review meetings would be held to monitor the progress and risks of the engineering collaboration. In addition to the project team meetings, a steering committee would meet every six to eight weeks to discuss the most important progress and risk issues identified in the project team meetings. Although Océ initially asked Motio to invest in a compatible CAD system, facilitating Product Data Interchange, it was agreed upon between Océ and Motio that Motio would not invest in such an additional customer-specific CAD system (ref: supplier account manager; Océ outsourcing project leader). A conversion to the Océ CAD-system would be made with help of an external supplier in the project stage when the Product Documentation is (almost) "frozen". Furthermore, guidelines on the general project phasing, design and safety standards were provided in a file. In the early stages of the collaboration, the Océ project leader of the finishing function invited Motio engineers over to discuss the Océ project phasing methods to them and to let them talk to engineers in the Delta project. The Océ R&D project team prescribed a number of components such as motors and stapler heads in the product design.

A number of unexpected issues arose during the collaboration. Firstly, we observed a number of technical development issues and changes in the timing of the overall project. The technical collaboration evolved using more than four prototype cycles and surpassing the originally planned development period by two years, which was caused by the delays in the overall project. These prototype cycles were characterised by a significant number of design changes, which were considered necessary by Océ to changing the requirements of the product and its interfacing apart from improvement of the functional performance, noise, safety, reliability and manufacturability aspects. Although Océ considered Motio's contribution to the concept of moving and controlling the staplers as valuable, other technical development issues initially made the R&D representatives critical about the effectiveness and efficiency of working with Motio. The R&D outsourcing project leader pointed to a difference in the extent to which Océ engineers put emphasis on functional performance and other quality aspects such as durability, reliability and noise levels. Although priorities had been written down in the engineering project plan, differences in interpretations and engineering style made it more difficult to find the correct development direction. For example, the collaboration with Motio and its second tier supplier concerning reliability tests revealed a different perception of the extent to which certain risks were considered acceptable. The Océ engineering project leader formulated it as follows: '*...their perception of quality is different from our perception of quality. We assumed that Motio had at least the same knowledge level as we did*'. The project manager at Motio agreed, '*the quality level of prototypes and drawings only became clear late in the collaboration*'. Conclusion is that both parties had a different approach of the item quality and the associated efforts in relation to the specific Océ application field. Another issue in the technical collaboration arose during the development of a printed board assembly (PBA). Océ considered the difficulties regarding exchanging design information between Motio and the PBA engineering partner, and ultimately itself, as problematic. Océ and Motio therefore discussed several alternative suppliers. For a while Océ accepted the collaboration about the design of the PBA with the second tier supplier proposed by Motio. However, at the end of the engineering phase Océ urged for a new production supplier given Océ's own disappointing experiences with this particular supplier. Motio, however, did not have this negative experience, but agreed to switch to a supplier suggested by Océ.

A third issue in the technical collaboration concerned the drawing conversion tasks for mechanical components. Originally, Motio called in the help of a third partner to convert the drawings to a compatible format which Océ would be able to control at the end of the development project. However, Océ's R&D team members had the opinion that the quality of the specification and industrialisation output did not meet the Océ-requirements yet, apart from the co-ordination of activities between Motio and supplier; they therefore decided to in-source these tasks.

A mainly organisational issue, which affected the technical collaboration, arose due to a changing team composition on both sides. This must be considered in the time frame of the project of almost 6 years. For Motio the fluctuations in team composition were partially caused by the sinus shaped waves of development effort caused by Océ. These dynamic fluctuations made it difficult to have the human resources available every time to carry out the design changes for the next prototype cycle while taking into account the capacity needs for other customers. Océ's team composition' was changing even more often, especially on the R&D side. The Delta project was subject to several delays, which stretched the planning, originally shared with the suppliers. According to Motio this resulted in additional costs and loss of knowledge and quality (ref: account manager and Motio project manager). An additional issue was the co-ordination of second tier suppliers. Motio considered the timing of involving various suppliers to consult them on manufacturability as difficult, because of the delays in the project and unexpected design iterations. Such unexpected iterations also put a lot of pressure on the cost price, as initial quotations were no longer valid. The collaboration also contained commercial issues, such as tough discussions on the tariffs and the number of engineering hours Motio charged in the light of the expected contribution and output. Océ believed that

Motio did not always inform them in time so that they could anticipate and take action against possible overruns (Océ engineering project leader). Océ also thought that Motio transferred more work to the second tier supplier than was agreed upon. Motio considered capacity outsourcing as their own responsibility.

A commercial issue arose between Purchasing and Motio, concerning the way Motio dealt with overhead percentages used on purchased components. In the end both parties resolved the issue, but it took much more effort than expected. The relationship was also affected by critical remarks at different levels in the manufacturing department regarding Motio's competence to assemble the MSU efficiently and effectively in typical Océ production quantities. The account buyer stated that although the R&D, Purchasing and R&D management appeared to have been involved in selection, the decision to outsource both the engineering and assembly of the unit had not been a fully committed one within the Océ organisation (ref. account buyer 1). Just before releasing the MSU, the account buyer stimulated them to visit Motio and discuss their worries. This led to a slow recovery of confidence on the Océ manufacturing side. At the end of the collaboration, it appeared that the supplier's contribution in designing the MSU had been significantly reduced. However, the MSU is now being assembled and scaled up without major quality problems. So far, the manufacturing representatives linked to the Delta project are satisfied with the output.

Both Océ and Motio have discussed the cooperation at different moments during the collaboration and attempted to identify any opportunities for future collaboration even in the direction of advanced development projects to be carried out by Motio. However, Océ and Motio have not yet succeeded. To some extent Océ had critical remarks whether Motio could provide the value added in Océ requested product and production engineering tasks. The supplier also had some remaining remarks. Motio experienced the collaboration as challenging because they perceived an inconsistency in the official and actual outsourcing policy, especially the different points of view between Manufacturing, Purchasing and R&D. The long project duration also posed problems in providing continuity in the project team. Also the content (man-hours) was smaller than the projects Motio normally fulfils. The account manager and project manager from Motio indicated that, *'decision-making processes and working procedures were still not always known during the collaboration. The time for decisions to be taken and to understand the requirements of Océ took was much longer than expected'*. The first project leader thinks that, *'within Océ R&D there are few people with significant experience in other companies. Such varied experience may be beneficial in starting up collaborations with suppliers because they can better anticipate where the potential misunderstandings exist at the supplier'*. Whereas Motio formed so-called 'customer focus teams' for other customers with partially-dedicated space and cross-functional operational account teams, the future business prospects with Océ meant that it was not yet economically feasible for Motio to set-up such a focus team. For this moment the Océ product is combined with a product for a different customer with comparable manufacturing standards thus providing Océ with adequate care for their products.

Overall, both Océ and Motio state that they have learned quite a lot in terms of understanding each other's business drive and processes. The atmosphere and communication is increasingly experienced as open and both parties are very much aware where the attention points in new projects will be (Motio project leader). Both parties intend to address the points for improvements in future projects.

4.5 Outcomes, issues and problems

We can make some initial observations about the results and the common and unique issues and problems encountered during the collaboration. First, the individual cases can be roughly assessed in terms of the efficiency and effectiveness of the development effort with suppliers. Effectiveness refers to the extent to which technical performance and part cost targets have been met, and efficiency reflects the use of resources in terms of time, engineering hours and co-ordination costs to achieve them. We provide a preliminary assessment in Table 4.4. We can see that Océ appears to have invested a lot of time and resources in setting up and managing the collaboration. Although a slightly better picture emerges regarding its effectiveness, we know that both in-project and after-project quality problems were reported. We will analyse and discuss the degree to which individual objectives have been met in Chapter 5.

Table 4.4 Development efficiency and effectiveness

Outcome	Case 1 Optics Unit WF1	Case 2 Optics Unit WF2	Case 3 PC-based controller	Case 4 Paper separation assembly	Case 5 Optics Unit SF 1	Case 6 Power supply heater	Case 7 Print Receiving Unit	Case 8 Moving Stapler Unit
Development Efficiency	Low	Low	Medium	Low	Low	Medium	Low	Low
Development Effectiveness	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium

We decided to search the cases in the first place for common and unique issues and problems that were present and experienced by the actors involved. Table 4.5 presents a list of these issues and problems.

Distilling these issues and problems and assessing how common they are throughout the case studies, provides us in Chapter 5 a good starting point for further analysis of the results. One of the reasons for doing so is that those issues that stand out may be symptoms of particular problematic managerial activities and lacking conditions. By examining possible patterns in terms of managerial activities and conditions and by contrasting the cases between high and low performing collaborations, we can better understand why and how Océ has achieved the results. We will not ignore the less frequently occurring but potentially important issues. Some unique problems can be understood by the presence of certain driving factors or by the lack of enabling conditions.

Table 4.5 Overview of encountered issues and problems during collaboration

Problems/ Issues	Optics Unit WF1	Optics Unit WF 2	PC-based Controller	Paper separation assy	Optics Unit SF	Heater Power supply	Print Receiving Unit	Moving Stapler Unit	# cases
1. Unexpected technical problems prototypes during development	✓	✓	✓	✓	✓		✓	✓	7
2. Doubts/discussion regarding supplier's assembly, test and production capabilities after collaboration started.	✓	✓	✓	✓	✓		✓	✓	7
3. Doubts/discussion regarding design capabilities of suppliers after collaboration started	✓	✓			✓		✓	✓	5
4. Transfer of design and or engineering tasks back to Océ.	✓	✓			✓		✓	✓	5
5. Doubts on correct supplier choice /lack of full internal commitment	✓		✓		✓		✓	✓	5
6. Lengthy in-project discussions on contract price elements	✓		✓		✓		✓	✓	5
7. Complex communication interface with supplier organisation	✓	✓	✓		✓			✓	5
8. Transfer of assembly/testing tasks back to Océ.	✓	✓	✓		✓				4
9. Hidden specifications (specs do not match functional behaviour)	✓		✓	✓	✓				4
10. Océ prescribing suppliers			✓	✓			✓	✓	4
11. Unexpected/undesirable divestment, acquisition, merger activities						✓	✓	✓	3
12. Changing first tier suppliers during project	✓		✓					✓	3
13. Part availability/supply risks/ safety stock policy	✓		✓		✓				3
14. Océ not able to limit changes in team composition			✓				✓	✓	3
15. Language/cultural differences	✓	✓			✓				3
16. Access to supplier's product and technology roadmap	✓		✓		✓				3
17. Lack of future projects/continuation at risk							✓	✓	2
18. Supplier not able to keep the same people on project team			✓					✓	2
19. Discussion on non-compatible CAD / Data Management systems							✓	✓	2
20. Océ rejecting second tier supplier choices by first tier supplier								✓	1
21. In project discussions on surpassing budgeted hours and timely communication thereof								✓	1
22. Unclear restrictive specification format			✓						1
23. (Timely) access to critical design info				✓					1
24. Discussion on warranty costs				✓					1

One of the top ranking issues is the occurrence of unexpected technical problems during development. These problems were related to a mixture of quality aspects such as functional performance, durability and non-conformance of delivered parts to the specifications. Secondly, in more than half of the cases, discussions took place regarding the feasibility of assembly and design responsibilities assigned to the suppliers. Doubts arose regarding the initial supplier choice. In some of these cases, these doubts resulted in a reduction in the extent of design outsourcing and in the level of assembly outsourcing. Sometimes, Océ decided or was forced to change suppliers during the project. In five cases, the part cost price, development costs and warranty cost discussions required lengthy discussions late in the project. Océ was also confronted with high risks regarding part availability and obsolete components. Short component life cycles endangered the achievement of production targets but also necessitated an increased effort in validating the new components in the Océ-specific machine environment. The sharing of technology roadmaps and the access to critical design info were particularly important (but somewhat unique) issues in the PC-based controller case. These issues raise questions as to how Océ selects its suppliers and plans the involvement in different projects. Furthermore, what does Océ do to create internal commitment and foster long-term relationships when it sets out a strategy for increasing supplier involvement? Are the conditions for such increased involvement really there? If not, how does it detect and mitigate these risks associated with developing parts with suppliers? Our analysis of the managerial activities and conditions in the next chapter intends to reveal which conditions are critical to capture the short and long-term benefits from supplier involvement.

4.6 Conclusions

In this chapter we have described the background of the copier and printer industry and introduced Océ, the subject of our case study. We have chosen to study the management of supplier involvement in a high-tech industry that has experienced both a technological and a market transformation, creating both opportunities and threats to incumbent companies. Océ, being a relatively small company and building on its own unique technology, is clearly under pressure to think even harder about how to combine internal and external resources to improve its competitive position. We presented a case study design and methodology that allowed us to study the phenomenon of supplier involvement and associated managerial activities in a longitudinal case study. Eight case studies were selected, concerning the development of eight parts with varying degrees of supplier involvement. They were embedded in six development projects. The majority of cases were investigated retrospectively, with two cases being still largely ongoing when the study commenced. This chapter also served to build the case history. The case descriptions yielded a first distillation of issues and problems encountered during the collaborations. It appears that in many cases the collaboration required much more time and resources than was expected, spurring doubts and scepticism about the true added value of involving suppliers in some parts of the organisation.

In the next chapter, we analyse the results of the collaboration in more detail and provide an in-depth analysis of the way Océ set-up and managed the collaboration with its suppliers. We do that by connecting the issues to the way in which relevant activities of the analytical framework were carried out. We also analyse the conditions that hindered and facilitated the effective involvement of suppliers.

Chapter 5
Managing supplier involvement in product development in a high-tech company: Case Analysis

5.1 Introduction

In the previous chapter we set up and described the case studies, including the methodology used to develop them. We concluded the chapter by developing a first insight into the efficiency and effectiveness with which Océ involved suppliers in different development projects. The issues and problems that were encountered in the eight collaborations evoked a number of questions regarding the way specific parts of the collaboration were managed and the extent to which certain critical conditions were present at the outset.

In this chapter we use the analytical framework for Integrated Product Development and Sourcing (IPDS) to analyse the eight case studies and the issues and problems presented in the previous chapter. As discussed in Chapter 3, the framework has four analytical building blocks: the results of supplier involvement, the managerial activities, the conditions enabling or hindering the management of supplier involvement, and the driving conditions affecting the need for, or form of, specific activities. The framework is used with two objectives in mind. Firstly, it helps to structure and translate the historical account of events related to the phenomenon into an analytical interpretation. We therefore measure the collaboration results and link the issues and problems to the managerial activities. We subsequently compare the cases in terms of differences in the extent and form of active execution of the different managerial activities, and in terms of the presence or absence of enablers and drivers. Secondly, it provides a first insight into the critical sets and patterns of activities and conditions that most strongly affect the short and long-term results of supplier involvement.

The chapter is structured as follows. We first present our propositions and analysis method. We next present the analysis according to the framework as: results, managerial activities and conditions. By comparing their patterns across the different projects and collaborations, we provide insight into the levers for effectively managing supplier involvement in product development in a high-tech company.

5.2 Case analysis approach/methods and propositions

In order to determine which managerial activities and conditions are most critical for effective supplier involvement, we first needed to take a number of steps to develop our initial propositions. We started by measuring the short and long-term collaboration results of supplier involvement. We then proceeded by connecting the problems and issues distilled from the cases in the previous chapter with the way in which Océ executed the *Project Management* and *Product Management* activities; this focused our attention on the most problematic cases (inefficient and/or ineffective). By contrasting successful and less successful cases, we intended to reveal possible dynamic patterns in the order and cycles of various activities. We considered the most successful case to be the one with the highest degree of attainment of short-term collaboration objectives *and* the fewest number of issues and problems. We expected Océ to have developed robust routines in executing 'Project' and 'Product Management' activities. Together with its relatively small internal resource base, Océ's ability to develop the right products at lower life-cycle costs appears to be increasingly linked to the effective management of supplier involvement. In particular, Océ needs effective decision-making and co-ordination processes within its development projects in order to bring its complex products successfully onto the market. We therefore argue that *Project Management* activities have a significant impact on the efficiency of the collaboration in terms of the development costs and the time needed to develop parts, whereas *Product Management* activities have the most impact on its effectiveness, in other words, the technical performance and cost of the part.

We analysed Océ's efforts in developing policies and guidelines, and the availability of relevant information and capable suppliers in advance or in the early phases of development projects. Given Océ's current dependence on R&D and suppliers and its intention to increase the role of suppliers in its development process, we expected Océ to have visibly organised and executed *Development Management* (DM) and *Supplier Interface Management* (SIM) activities. We expected *active* execution of 'DM' and 'SIM' prior to the start of the collaboration to speed up decision-making in planning the collaboration and enable the effective execution of product management activities, resulting in improved designs. A second expectation was that both management areas were instrumental in capturing long-term collaboration results, because of their permanent character and long-term horizons.

After having revealed such dynamics, we enlarge our scope of analysis by examining the presence of 'enabling' and 'driving' conditions. Enablers are those factors that strengthen the ability of Océ to effectively and efficiently manage supplier involvement in the four management areas. The absence of these enablers would be likely to create barriers for the effective management of supplier involvement. The drivers are market and organisational variables, characterising the context in which the collaboration takes place. They affect the appropriate amount of resources invested in the management areas and the organisational mechanisms to co-ordinate collaborations with suppliers.

5.3 Analysis of the Integrated Product Development and Sourcing results

5.3.1 Short-term collaboration results

The first step in analysing the cases was to measure the *short-term collaboration results*. They were measured in terms of the degree of attainment of four different development targets, and were based on the search for objective (written) data regarding targets and actual performance, whenever possible. If such measurements were not possible, judgements from key informants[15] were used. Three different types of informants within the company were asked to provide data on the different performance indicators. For the *technical performance* indicator, the R&D engineer was asked to judge the degree to which the prototypes met functional, durability and reliability targets and conformed to specifications at the release of the part; judgments were on a scale from 1 to 5, where a '3' indicates that the performance was 'on-target'. Wherever possible, this judgement was then compared with the 'actual-to-target' manufacturing and field performance data[16]. The initial judgement of the engineer was then adjusted downwards if the manufacturing and field performance were worse than the official target. We measured the *part cost* by comparing the initial purchasing estimate[17] provided by the account buyer to the final contract price. In order to measure the third performance indicator, *part development cycle time*, the R&D engineer was asked to judge the degree to which the planning of intermediate prototype cycles up until the first production delivery had been subject to delays, and the degree to which the development had affected the overall project planning. These scores were averaged and rounded up or down based on the comments from the engineers involved. Finally, regarding the *part development costs*, the R&D engineer was asked to provide objective data on the degree to which engineering hours and prototype cost targets were met. It is important to notice that in the majority of cases no specific budget targets were available for that part (for all cases except the PRU and MSU cases). The targets were substituted by the expectations of the engineers involved. Table 5.1 gives an overview of the overall results, individual scores, including comments, can be found in Appendix 5.1. We can see a specific pattern of performance. Océ succeeded in meeting its own technical performance targets in 50% of the collaborations. In 37.5% of the cases, the development time for parts did not undergo any temporary delays. However, none of the collaborations *caused* a project delay. This concurs with previous findings that state that supplier involvement does not speed up the overall product development time (Zirger and Hartley, 1997). Striking here is the pattern related to 'part cost' and 'development costs'. Océ appears to meet both targets in only 25% of the collaborations. We can also see that no collaboration performed much better than the initial targets, the exception being the part cost performance of the paper separation assembly.

These results need to be interpreted carefully, taking into account specific contextual circumstances contributing to the deviations.

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[15] The development engineer was the key informant for the part technical performance, part development costs and part development time. The account buyer was the main informant for the part cost, although the development engineer provided the initial R&D cost target. The manufacturing quality engineer was asked to provide data on the part's manufacturing and field performance.

[16] Océ primarily uses a Parts Per Million indicator (PPM) to measure manufacturing quality. Wherever possible we looked for information regarding field performance for each part. We were able to find information for case 1,2,3, 4 and 5. If PPM targets were not met and field problems were also reported, the scores were adjusted to a below target score on technical performance.

[17] In some cases, the R&D estimate was the first available target and served as the initial target.

Table 5.1 Short-term collaboration results

	Part Technical Performance					Part Cost					Part Development cycle time					Part Development costs				
Cases	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1. Optics Unit WF1		■				■						■				■				
2. Optics Unit WF2			■				■						■					■		
3. PC-based Controller		■						■				■					■			
4. Paper separation assy	■									■		■					■			
5. Optics Unit SF		■				■						■				■				
6. Power Supply			■				■						■					■		
7. Moving Stapler Unit			■				■					■				■				
8. Print Receiving Unit			■				■						■				■			

1 = much worse than target; 2 = slightly worse than target; 3 = on target; 4 = slightly better than target; 5 = much better than target

In addition to the supplier, Océ itself may have contributed to the (positive and negative) results in these cases. The results regarding the *part's technical performance*, (optics unit WF1 and SF cases) have received mixed judgements. The engineers considered the technical performance at market introduction to be reasonable, because in the optics unit WF1 case the Star project was introduced with unprecedented print speed/quality performance, and the Beta project was well-accepted in the market. The functional performance of the WF2 was not solely achieved by Optico's standard product, but was the result of an extra Océ measure (ref: electronics engineer). This caused several people to make their final judgement more positive. However, unexpected technical problems emerged during the development and undermined the performance in terms of durability and conformance to specifications[18]. In the case of the MSU, the final technical performance was satisfactory, meeting the target with low rejection rates. However, the performance should be interpreted with the large number of unexpected engineering problems in mind. The PC-based controller initially performed below target in terms of meeting the Océ specific product and assembly specifications, and had some interaction problems when new components were introduced. We can see that the separation assembly suffered from functional problems after market introduction.

To analyse the *part cost performance* we need to interpret the results carefully. Almost all of the cases ended up with a higher contract price than was striven for. Both the paper separation assembly and the PC-based controller had satisfactory cost price levels. However, there are three important points that we need to consider and which change the effect of these results on the final project performance. First of all, the paper separation assembly had a lower cost price in absolute terms than the PC-based controller. Therefore, the impact of a better-than-target cost price on the final product cost price was barely visible in the paper separation assembly case. Secondly, the cost price targets of both parts did not include an assessment of all relevant life cycle costs[19], which negatively affected the cost performance. Thirdly, cost price estimations by R&D and Purchasing did not initially include the same cost elements; each

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[18] Based on the number of production rejections and service replacements

[19] High levels of safety stock, rejection and/or service replacements in the years after market introduction.

department was responsible for different cost elements during different periods. This resulted in difficulties in target setting and monitoring (PRU and MSU cases).

The *part development cycle time performance* shows a peculiar pattern. Although all collaborations (except the WF2 optics unit and heater power supply) encountered additional prototype cycles, they were not on the critical path of the overall project planning.[20] The PC-based controller is a special case, where ChainPC introduced the next generation of PCs or components even before the Moon project was introduced onto the market. This situation required extra human resources capacity to prevent the market introduction and delivery dates from being endangered. Earlier studies by Eisenhardt and Tabrizi (1995) pointed out that involving suppliers in high pace development contexts has a lower impact on improving development time compared to low-pace development environments. However, no studies have examined the managerial requirements for involving suppliers who are active in a high velocity environment, but in a lower pace development context such as the copier and printer development context. This calls for more in-depth examination of the managerial processes adopted to plan and execute such collaborations. Finally, if we look at the *part development costs*, we can see a tendency in these cases to use significantly more engineering hours and, to a lesser extent, more prototyping costs than were originally foreseen. Specifically, the MSU, optics unit WF1 and SF cases were subject to higher development costs than expected.

In summary, we cannot contend that these supplier involvement cases are 'black' or 'white' successes or failures. The cases demonstrate the mixed results of supplier involvement in the context of a specific collaboration episode in a development project. It would therefore be interesting to also analyse their involvement in terms of their (potential) long-term results.

5.3.2 Long-term collaboration results

In addition to measuring the degree to which the specific development targets were met, we asked the engineers and buyers involved to what extent they perceived the collaboration had resulted or was expected to result in a number of long-term benefits[21]. In Table 5.2 we can see that 'a more efficient and effective future collaboration' is expected to occur in several collaborations as a result of the learning experiences of the people involved. Based on the problems and discussions encountered in this collaboration, both buyers and engineers think they will be able to work together on part design faster and more effectively next time. Overall, this long-term benefit appears to be mentioned most frequently by the engineers and buyers involved. Only in those collaborations with low supplier involvement were no such learning experiences observed. In the heater power supply case the additional learning experience was not considered to be high because of the extensive previous experience and knowledge about each other's needs and capabilities. Although the first two optics unit cases took place in parallel for several years, the learning experiences concerning technical and organisational

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[20] Delays elsewhere in the project allowed the collaboration to solve problems according to the adjusted planning.

[21] Due to the qualitative nature of these benefits and the lack of follow-up collaborations in a number of cases, 'expected' results were the only possible frame of reference.

issues encountered with Optico were only shared informally and not very intensively. In a second project with Sorto it was asked to co-develop a similar PRU, but none of the long-term learning benefits were captured due to the premature termination of the collaboration. This raises the question of whether and to what extent Océ effectively transferred the learning experiences.

Table 5.2 Long-term collaboration results

Long-term Collaboration results	Case 1 Optics Unit WF1	Case 2 Optics Unit WF2	Case 3 PC-base Controll	Case 4 Paper Separatio Assy	Case 5 Optics Unit SF	Case 6 Power Supply	Case 7 PRU	Case MSU
Improved efficiency and effectiveness of collaboration	Medium	Medium	Medium	Low	Medium-to high	Medium	Medium	High,
Improved access to supplier technology	Medium	Medium	Low	Low	Medium	High	Low	Low
Extent of aligned technology and product roadmap	Medium	Medium	Medium	N.A.	Medium	Yes,	Low	Low
Transfer of solutions developed during the collaboration to other projects(*Econ. of scope*)	Low	Low	Low	Low	Low	Potentially	Low	Low

In some collaborations, an improved *access to supplier's technology and knowledge* was recorded, but was limited. In the case of Optico, the two initial projects increased the access to the supplier's technology, and in particular to its LED design and production technology (ref: development/ manufacturing engineers). However, Océ had to develop most of the functional and design-related knowledge internally. Therefore, Océ did not improve its access to other capabilities as much as it would have liked. In the PRU case, the access was not improved as much, as it depended on the experience of the supplier's senior engineer and the divestment of internal plastic moulding production. The *alignment of technology roadmaps* was particularly important in the optics unit cases and the PC-based controller cases, whereas such a benefit was not considered in the paper separation assembly case. The collaborations in the WF1 and SF1 optics units did not immediately result in an aligned roadmap. However, in the years following, the actual production numbers (i.e. sales for the supplier) slowly increased the motivation to share somewhat more information with R&D. The dialogue on future technological needs and Optico's investment planning grew more intensively in the years that followed. In the PC-based controller case, it took several years of collaboration before the exchange of information regarding future planning improved. In line with previous literature (Monczka, 2000) these observations suggest that it takes a considerable time to achieve roadmap alignment, because it is likely to require information sharing, which presupposes a willingness to share and also an appropriate channel by which to share and discuss. We did not find many instances of the *transfer of solutions and concepts in one collaboration to other projects* in our analysis. Although the collaboration in the power supply case resulted in a solution that could be used in other projects, this has not yet occurred. The Moon project has effectively marked a starting point towards a platform policy to increasingly use PCs in other projects.

We have encountered the same mixed pattern of supplier involvement results as reported in previous studies. Specifically, we have observed a distinctive pattern of time and resource- consuming collaborations, encountering more technical problems than anticipated and with relatively successful scores on most performance dimensions. We have also observed the presence of (potential) long-term collaboration benefits. Capitalising on learning experiences, improving access to supplier's knowledge bases and aligning technology roadmaps between the customer and supplier organisation can put the apparent negative results in the project studied in a more positive perspective. However, we need to further analyse how Océ organised and managed its supplier involvement, since the benefits were not achieved in all the collaborations.

5.4 Analysis of the Integrated Product Development and Sourcing activities

We decided to further investigate the way Océ organises and manages its supplier involvement by analysing the managerial activities in the four different management areas of the IPDS framework. We analyse the data by going back to interview transcriptions and mark passages that can be linked to activities in the framework. Similarly, the issues and problems were linked to the activities as to observe possible problematic and effective activities. Analysing how the managerial activities are carried and linking issues and problems to one or more of these categories can enrich our understanding which ones have been critical and affecting the performance of the collaboration (short- and long-term collaboration results). In contrast to the original order of the management areas suggested in the framework, we start our analysis by investigating how the 'Project Management' (PJM) and 'Product Management' (PDM) have contributed to an effective collaboration. We then examine the extent to which Océ actually prepared its collaborations through visible execution of Development Management (DM) and Supplier Interface Management (SIM). One of the reasons for revising the order is that, at first sight, the explanations for the observed short-term collaboration results seem to be directly connected to the short-term managerial actions and the decisions in the PJM and PDM areas. We then try to explain why some of the long-term benefits were or were not captured, by analysing the extent of the execution of the permanent managerial activities in DM and SIM.

5.4.1 Project Management execution characteristics and effects

In the previous sections we observed the relatively successful involvement of Cerel in the development of the power supply compared to the other cases. Initially, we found that most cases (cases 1,3,4,5,7 and 8) were characterised by higher development costs, longer development times and unexpected intermediate technical performance problems. Although Océ solved some of these technical problems, a number of quality problems persisted when the final product was launched onto the market (cases 1,3,4 and 5). We examined the issues distilled in Chapter 4 in terms of their connection with the various managerial activities from the *PJM area*. In successful collaborations, we expected Océ to have been able to achieve a higher quality of decision-making in the planning area and an appropriate operational co-ordination of development activities. Table 5.3 gives an overview of these activities, where the first column contains the issues and have been put in the case boxes in which they occurred. If we compare the pattern of planning and execution activities in the heater power supply case (case 6) with the other cases, two peculiar patterns emerge. On the one hand, the first collaboration is characterised by fast decision-making associated with the four planning activities. These decisions largely ensured a smooth collaboration with Cerel in the Gamma project. The clear demarcation of the power supply as a technology/function area and the presence of potential competent suppliers were particularly helpful. All departments agreed to the final supplier choice and its expected contribution was not subject to much discussion. The discussion focused on solving a potential norm problem. The two different moments of involvement were also well-timed and allowed the overall project to perform the machine tests with the prototypes delivered on time (ref: account buyer and R&D engineer). The development activities with Cerel were co-ordinated efficiently, using a simple and effective communication interface. Although technical issues had to be addressed, they did not differ from the usual iterations that are necessary to realise a power supply. On the other hand, cases 1,2,3,5,7 and 8 demonstrated a different pattern. In these cases a low/medium effort was spent on defining which parts were candidate for outsourcing and on finding and choosing an appropriate supplier. This was followed by a quick start to the technical collaboration with the supplier. In the majority of cases a variety of technical and organisational problems soon emerged during the collaboration, resulting in increased co-ordination between Océ and the first and second tier suppliers. During the evaluation of product designs (prototypes), in particular, the development teams experienced a disappointing intermediate quality level of design and engineering. In all these cases, both the co-ordination effort from R&D, Manufacturing and Purchasing and doubts about the supplier's true technical design engineering or manufacturing-related (e.g. assembly, fine-tuning, testing) capabilities increased. These doubts subsequently fostered the perceived need to increase Océ's internal control of development, and later on of assembly activities. In most of the cases a pattern emerged varying from prolonged discussions regarding supplier choices or possibly transferring outsourced development and assembly-related tasks back to Océ, to actually reversing these earlier decisions. The paper separation assembly case is characterised by a very limited role of the supplier during development, and we therefore do not observe this pattern of reversing of earlier decisions. Although co-ordination problems did exist, they occurred during the regular production phase. These patterns suggest that the quality of the decisions taken in the planning activities strongly affect the resources needed to co-ordinate supplier development activities and to solve the technical problems through increased internal control on specific outsourced tasks. In order to better understand how Océ actual went about taking these decisions in the successful and less successful cases, we now discuss the most striking differences for the individual PJM activities.

Table 5.3 Project Management activity characteristics

Project Management Activities	Issues/ Problems encountered	Optics Unit WF1	PC-based Controller	Optics Unit WF2	Paper Separation Assy
Planning					
PJM 1 Determining specific Develop-or-Buy solutions	**4** Transfer of design tasks **8** Transfer of assembly tasks	R&D driven, Unit identified by R&D search for black box development; Fast initial decision (4,8)	R&D-marketing driven choice to choose the technology (8)	R&D driven: Project architecture driven choice (4)	R&D driven Fast initial decision
PJM 2 Selecting suppliers for involvement in the development project	**5** Supplier choice questioned **7** Océ prescribing 2nd suppliers to 1st tier supplier **13** Changing 1st tier supplier during project **19** Océ rejecting 2nd tier supplier choices by 1st tier supplier	R&D driven. No real transparent cross-functional selection process. No audit in advance (5)	Non-transparent (multiple management and project members). Initially barely any Purchasing involvement. More involvement in 2nd supplier. No extensive audit/assessment (5,13)	Purchasing involved, natural choice based on existing strategic relationship (5)	Buyer was involved (late) followed standard Request For Quotation procedure
PJM 3 Determining the extent ('workload') of supplier involvement	**2** Discussion supplier manuf. capabilities **3** Discussion supplier design capabilities **4** Transfer of design/eng tasks back to Océ **8** Transfer of assembly tasks	Initially black-box, No validation in advance (2,3,4,8)	Standard supplier product initially chosen No (2,8)	Explicit R&D choice for standard supplier product (2,3,4,8)	Implicit R&D decision. No time spent on deciding on extent of involvement: natural limited involvement
PJM 4 Determining the moment of supplier involvement	**13** Changing 1st tier supplier during project	Involvement in concept development phase: Involvement of Optico is triggered by failure previous collaboration (13)	Involvement in engineering phase: Involvement of Chain PC is triggered by failure previous collaboration (13)	Involvement in concept development phase	Involvement mid-engineering phase
Execution					
PJM 5 Co-ordinating development activities between suppliers and manufacturer	**1** Unexpected technical problems with 1st tier supplier **7** Unstable/ Complex communication interface with suppliers	Communication was initially difficult. Use of intermediary facilitated, but Océ gradually took over several design related tasks (1)	Communication difficult Many different actors on both sides involved because of validation and assembly problems (1,7)	Coordination occurred via an R&D engineer from another project and the buyer.Worked well to some extent (1)	Simple Engineer-Engineer and buyer sales person interface.
PJM 6 Co-ordinating development activities between different 1st tier suppliers		via Océ. No active communication between two 1st tier suppliers	via Océ. No active communication between two 1st tier suppliers	via Océ. No active communication between two 1st tier suppliers	via Océ. No active communication between two 1st tier suppliers
PJM 7 Co-ordinating development activities between 1st tier suppliers and second tier suppliers	**10** Océ prescribing 2nd suppliers to 1st tier suppliers **11** Unexpected technical problems involving 2nd tier supplier	R&D led R&D selected Lenses at 2nd tier supplier. Purchasing involved in discussions between R&D and 2nd tier suppliers (11)	R&D selected Lenses at 2nd tier supplier	R&D designed PBA; arranged 2nd tier contract manufacturer and to deliver PBA to Chain PC's assembly location	R&D arranged contact for regular delivery of rubber compound to 1st tier supplier Quality control issues, payment
PJM 8 Ordering and chasing prototypes		R&D led	R&D led Prototype cycles not synchronised with life cycle supplier components	R&D led	R&D led

Table 5.3 continued Project Management activity characteristics

Project Management Activities	Issues/ Problems encountered	Optics Unit SF	Power Supply	PRU	MSU
Planning					
PJM 1 Determining specific Develop-or-Buy solutions	**4** Transfer of design tasks **8** Transfer of assembly tasks	R&D driven Standard supplier product Fast initial decision (4,8)	R&D identified the Power Supply Unit	Initially, R&D driven. Unit with clear interfaces and functional character. (4)	R&D driven Result of KIC-driven search for units for increased supplier involvement. (4)
PJM 2 Selecting suppliers for involvement in the development project	**5** Supplier choice questioned **7** Océ prescribing 2^{nd} suppliers to 1^{st} tier supplier **13** Changing 1^{st} tier supplier during project **19** Océ rejecting 2^{nd} tier supplier choices by 1^{st} tier supplier	R&D driven. Some involvement of buyer. No extensive audit/ assessment (5)	Joint R&D Purchasing decision. Supplier was a pre-selected supplier	No Purchasing involvement in selection of Engineering Partner. Active involvement in 2^{nd} supplier choice. No official audit/ Some management assessment (5, 7, 13)	No extensive comparison among alternative suppliers.Cross-functional Selection, No official audit Some management assessment (5,7,19)
PJM 3 Determining the extent ('workload') of supplier involvement	**2** Discussion supplier manuf. capabilitie **3** Discussion supplier design capabilities **4** Transfer of design/eng tasks back to Océ **8** Transfer of assembly tasks	Initially Black box. Not much cross-functional validation in advance (2,3,4)	R&D and Purchasing determined Supplier involved based on potential future problem and responsible for black box development	R&D driven/ Diminishing extent of involvement. No validation in advance design. Quality level design was not high in relation to desired extent of supplier involvement (2,3,4,8)	Initially Blackbox. Not much cross-functional validation (2,3,4)
PJM 4 Determining the moment of supplier involvement	**13** Changing 1^{st} tier supplier during project	Involvement in concept dev. phase: Moment is result of technical need to have proto-types to validate the functional concept	Timely Moment well in advance of project	Involvement in engineering phase Involvement of Sorto is triggered by failure previous collaboration (13)	
Execution					
PJM 5 Co-ordinating development activities between suppliers and manufacturer	**1** Unexpected technical problems with 1^{st} tier supplier **7** Unstable/ Complex communication interface with suppliers	Communication was initially difficult. Use of intermediary facilitated, but Océ gradually took over several design-related tasks (1,7)	Direct and simple interface between R&D, Purchasing and supplier counterparts	Initially co-ordination did not work properly between and within the supplier organisation; solved partially by arrival of 2^{nd} Océ engineer	More than 15 persons in collaboration identified in different disciplines and managerial levels. Coordination difficult with changing team composition
PJM 6 Co-ordinating development activities between different 1st tier suppliers		via Océ. No active communication between two 1^{st} tier suppliers	via Océ. No active communication between two 1^{st} tier suppliers	via Océ. No active communication between two 1^{st} tier suppliers	via Océ. No active communication between two 1^{st} tier suppliers
PJM 7 Co-ordinating development activities between 1st tier suppliers and second tier suppliers	**10** Océ prescribing 2^{nd} suppliers to 1^{st} tier suppliers **11** Unexpected technical problems involving 2^{nd} tier supplier	R&D selected Lenses at 2^{nd} tier supplier Purchasing also involved in discussions between R&D and 2^{nd} tier suppliers (11)	No co-ordination necessary, except for components and increased assembly level	R&D and purchasing are somewhat involved in p No substantial problems in co-ordinating these activities (10)	Océ perceives problems in development activities between Motio and PBA suppliers (10,11)
PJM 8 Ordering and chasing prototypes		R&D led	R&D led	R&D led Long period between Engineering and production ramp-up. Initially prototype cycles not synchronised	R&D led Long periods of apparent rest between prototype cycles

The first activity, *determining the project specific develop-or-buy solution,* appeared to be strongly R&D driven and is not characterised by early cross-functional project decision-making. For the heater power supply, the range of develop-or-buy options to consider had become more definite for the power supply technology as a whole, thus speeding up the decision-making process. At that time Océ had no clear co-development track record in the technological areas of controllers, print heads, stapler modules or paper-handling modules. They tended to strive for high external involvement, due to their initial lack of time and engineering resources for the project. A more active discussion between Purchasing, Manufacturing and R&D was held regarding the level of assembly outsourcing. We can see that they wanted to integrate the two decisions and find one supplier that could fulfil both the expected role in product development and assemble the part. However, this would require an early involvement of internal departments to demarcate the buy-part in such a way that a clear, independent and testable or measurable part could be defined. In the optics unit WF2 and PC-based controller cases the develop-or-buy solution was clear: they were standard supplier products. However, these products were not able to meet Océ's functional requirements. Given Océ's initial willingness to adapt the requirements for the PC-specifications, some customisation of the design was necessary, rendering the intended policy only partially effective.

After deciding on a particular desired develop-or-buy option, *suppliers are chosen* following a selection process. Although supplier selection is officially a cross-functional decision-making process, it does not appear to be transparent and does not always ensure an initial integrated assessment of relevant capabilities and risks by all contributing departments. In our case studies the initial selection criteria and assessment results were either not well documented or not communicated throughout different levels of the organisation. This resulted in a low commitment and sometimes significant difficulties in anticipating or responding efficiently to some of the risks associated with a particular supplier choice. This was particularly true for collaborations that deviated from earlier, routine collaborations. When analysing the successful power supply case, we can see that the selection decision was taken early and jointly by Purchasing and R&D. Moreover, the presence of experienced suppliers in the supply base facilitated the supplier search and selection activities, thus reducing the search and contracting effort. In contrast, in three of the cases (optics unit WF1, PC-based controller, PRU cases) new suppliers had to be reselected during development or the final selection of the supplier for production was strongly questioned by different representatives (MSU, PRU PC-based controller cases). In these cases the initial supplier choice had been driven by R&D technical considerations. Although a variety of actors were involved (including Purchasing, Manufacturing and, in the PC-based controller case, sales companies), they were sometimes involved too late to create a committed choice or to assess the critical testing and manufacturing capabilities. Pragmatic assessments were made, usually by means of a visit to one supplier and asking questions about reference customers, the size of the engineering department and the type of CAD systems. In most cases no formal supplier organisation audit took place when the supplier was chosen for involvement in the project.

The occurrence of a number of technical problems can be partially attributed to the decisions taken in the activity of *determining the extent of supplier involvement*. All cases suggest that none of the project teams had a formalised procedure to validate what the most appropriate workload and responsibility would be regarding development of the part. The actual decision was often taken by R&D project representatives and their engineering manager. In five cases (1,3,5,7 and 8), we observed increasing efforts by Océ on specific development and assembly tasks[22] during the collaboration that were originally considered to be part of the supplier's workload. This marks a tendency by Océ to increase its control by taking over some of these tasks from the suppliers. In contrast, in cases 4 and 6, we note that the actual supplier contributions matched Océ's expectations regarding the desired supplier role. In the PRU and MSU cases expected deliverables were written down in a project plan. However, no significant validation activities beforehand could be observed, apart from an initial informal assessment of general capabilities during supplier selection. In fact, few suppliers appear to have been extensively consulted regarding the risks associated with the expected workload. One electronics engineer in the optics unit cases argues that 'Océ's intention to set-up a collaboration according to a black-box development approach, should have been accompanied by a joint discussion and agreement with Optico'. Moreover, Océ did not always have the right design information (requirements/specifications/prototypes) and was not able to offer the supplier a sufficient degree of stability in the requirements. In the PC-based controller case, we observed an initial tendency to prescribe performance ranges for certain components that were too strict, thereby increasing the effort on both Océ and the supplier's side to deal with component obsolescence. In the optics unit cases, Océ and Optico could not determine all specifications relevant to meet the functional. This was not entirely the supplier's fault, but can also be attributed to the lack of a lack of (but growing) knowledge available within Océ. In the PRU case we observed a migration from a black box development, when the engineering company was involved, to a lower 'detailed design responsibility' when Sorto became involved. However, the design information and prototype provided by Océ was of insufficient quality to start with production engineering, which resulted in a greater input from Sorto than expected but also in additional development costs.

Regarding the last the activity, ***determining the moment of involvement***, the case evidence underlines the importance of this decision variable to efficiently deal with the co-ordination of multiple suppliers. A special pattern of involvement can be detected in the power supply case, in which the supplier was involved before the Gamma development project started and was involved again during the development phase for the actual realisation of the power supply concept. This appears to have contributed to effectively reducing the non-compliance risk for the Gamma project. In most of the cases R&D drove the decision of when to involve a particular supplier. According to the engineering project leader, 'Purchasing does not have much interest in determining when a supplier should be involved. It is R&D that wants to outsource engineering capacity. So the phase in which to involve a supplier and the moment within the selected phase is a decision taken (implicitly) by R&D'. In some cases the involvement may have been too early from the supplier point of view. Motio and Sorto both wanted to move to production of the parts, but significant delays caused by Océ itself made them uneasy and caused problems for Motio in terms of availability of their engineers for the Delta project.

[22] Varying from electronics or mechanics design, production engineering and fine-tuning and testing.

We can see that the effort in the PJM execution area rose substantially due to the problems in the planning activities for various collaborations. The way in which the *co-ordination of development activities* occurred between Océ and different suppliers gives us an additional understanding of the increase in development costs. Firstly, the coordination of development activities between Océ and suppliers was not always supported by a clear communication interface and agreements. At Océ, multiple R&D representatives were involved in the development of parts depending on the variety of engineering disciplines and technologies involved (e.g. mechanics, electronics, optics and software) and the workload assigned to the supplier. Several R&D employees co-ordinated their respective aspects of the total design and engineering work for each part. Within one development project, a supplier often communicated with several R&D engineers (optics 1,2,3, MSU, PC-controller) a manufacturing engineer and an account buyer for a specific part. Across the different projects the supplier usually faced a different group of Manufacturing and R&D engineers. Some suppliers found the organisation to be confusing (PRU, MSU, PC-based controller case). In the power supply case, an effective co-ordination was facilitated by the clear communication interface and the intense and early communication leading up to the Gamma project. In the PRU case the *adapted* communication interface for the technical collaboration was considered to be a strong contributor to the supplier's ability to advance the prototype engineering. In the optics unit cases, language and cultural differences complicated the communication between Optico and Océ. Furthermore, only a limited number of Océ representatives were allowed to visit the supplier, thus limiting the frequency of face-to-face communication. In this case, the best compromise was to communicate by fax and to allow engineers of one project to collect questions and look after interests from other projects (optics unit WF2). After a while, some of the communication was channelled through an Asian intermediary; this streamlined some of the communication. However, given the high technical complexity of the optics unit, we could argue that the co-ordination was not initially fit for a situation with a complex design and hidden specifications. In the PC-based controller case, the complexity of the co-ordination process was severely underestimated by all levels in the organisation. A significant amount of resources had to be invested in the co-ordination of different development and operational activities (testing, assembly preparation, logistics, and service activities). Both organisations were involved in a continuous effort to adapt their organisations and processes beyond the specific collaboration in the Moon project. It appeared that an understanding of the supplier's internal organisation and its decision-making units for specific development, manufacturing, logistics and service related issues, was critical for finding an appropriate communication interface.

In addition to the direct co-ordination of development activities between Océ and its 1st tier suppliers, some technical problems and increased development costs can be traced back to the way in which Océ and the 1st tier supplier co-ordinated the activities with second tier suppliers. In a number of cases, Océ played a growing active role in the *co-ordination with second tier suppliers*. Coordination varied from persuading the 1st tier to change 2nd tier supplier or to strongly urge to choose a second tier supplier approved by Océ (as in the MSU case). The degree of co-ordination used is a trade-off. Océ lacked confidence in the second tier supplier proposed by its first tier supplier (MSU case) and perceived that it would have greater leverage if it continued its business with a particular supplier who was also a 1st tier supplier (PRU, MSU). Furthermore, in the optics unit SF and the WF2 cases, due to the significant interaction between the print head and lens in combination with their customer-specific application, Océ increased the degree of direct co-ordination with the second tier lens supplier. The cost of such interference was in the increased discussions and disagreements when determining who was responsible for technical problems pertaining to the second tier supplier. Another important issue concerned the creation of clear *expectations* and agreements with the 1st tier supplier regarding its role in co-ordinating different development tasks with second tier suppliers. If this was not properly discussed, misunderstandings resulted in increased engineering hours and part cost price (MSU case).

Analysing the last activity in the execution area of project management, *chasing of prototypes during development*, reveals the challenge of synchronising the prototyping and testing cycles between the manufacturer and supplier. In the PC-based controller case, the chasing of prototypes was characterised by the project team's attempts to achieve stability when replacing the tested prototypes with newer versions introduced by ChainPC. In the PRU case, although Sorto responded well to the initial requests from the second Océ engineer to speed up its prototype cycles, their time advantage was largely lost due to delays in the Delta project. In the MSU case, Motio stated that the long periods with relatively low workloads, followed by brief intense communication and pressure to deliver prototypes on time, were difficult to synchronise with their allocation of internal engineering capacity. Therefore, if 'prototype build test cycles' are to occur effectively, differences in planning and operating cycles between the manufacturer and supplier must be analysed beforehand. It is critical that communication channels are in place to communicate planning changes in time, allowing the supplier to achieve responsive resource allocation and to speed up development.

In summary, we can observe that the project management activities were executed in significantly different ways in the successful heater power supply case and the majority of the other cases. Failing to verify and agree with the supplier in advance about the expected supplier contribution to development and assembly of the part, and providing inappropriate design information, can explain the occurrence of increased levels of time and human resources required to co-ordinate development activities, which in turn results in higher development costs. The process of selecting the supplier and determining their extent of involvement are therefore critical in anticipating and addressing the technical and organisational risks associated with particular supplier choices and workloads outsourced.

5.4.2 Product management execution characteristics and effects

We now shift our analytical focus to how Océ actively deployed PM activities to effectively contribute to the improvement of the part design of those parts developed with external suppliers. We expected these activities to strongly affect the technical performance and cost price of the part. Table 5.4 gives an overview of the characteristics of these activities per case.

Table 5.4 Product Management activity characteristics

Produc Manage ment	Issues and Problems	1 Optics Unit WF	2 Optics Unit WF2	3 PC-based Controller	4 Paper Separatic Assembly	5 Optics Unit SF	6 Power Supply	7 PRU	8 MSU
PDM 1 Providing information on new products and technologies being developed or already available in supplier markets	9 Hidden specifications Increasing customisation	Primarily by R&D Limited *(Issue 9)*	Moderately	Moderately Info was built up during project *(Issue 9)*	No *(Issue 9)*	Info was built up and provided during project Not all available right from start *(Issue 9)*	Extensively	Limited Few readily available PRUs that could be readily integrated	Limited No supplier market for the MSU partexisted. Stapler heads suppliers were readily available
PDM 2 Suggesting alternative suppliers, products and technologies that can result in a higher quality of the final product	10 Océ prescribing 2^{nd} suppliers to 1^{st} tier suppliers 19 Océ rejecting 2^{nd} tier supplier choices by 1^{st} tier supplier	Limited visible contribution from Purchasing. One supplier was willing	Purchasing suggested alternative suppliers (that were already known to R&D)	Limited contribution from purchasing; grew in subsequent projects *(10)*	No alternatives were actively investigated in this project. Purchasing involved after concept choice was fixed *(10)*	Limited contribution from Purchasing. R&D investigated 2 potential alternative technologies	Purchasing and R&D consulted two alternative suppliers in the existing supply base	Purchasing made suggestions in the 2nd round 2^{nd} R&D – engineer suggested alternative 2^{nd} tier suppliers and technologies *(10)*	R&D and Purchasing considered a limited set of alternative suppliers (10, 19)
PDM 3 Evaluating product designs in terms of part availability manufacturability, lead-time, quality, and costs	1 Unexpected technical problems during development 6 Lengthy discussions on different part cost elements 8 Transfer of manufacturing tasks back to Océ. 14 Part availability /supply risks/ safety stock policy 22 Timely access to design info	R&D leading Long evaluation times. Persistent risks on all evaluation dimensions *(1, 14)*	Actual evaluation feedback by Purchasing and Engineer from other project *(1)*	R&D leading for technical aspects, Purchasing and Manufacturing confronted with part availability and quality issues. *(1,6,14, 22)*	R&D leading for technical aspects. Dominant focus on technical problems *(1,14)*	R&D leading for technical aspects Long evaluation times. Persistent risks on all evaluation dimensions Long transition period towards production *(1,6)*	R&D leading for evaluating functional performance Purchasing evaluated costs. Manuf Eng discussed Assembly issues Long transition period towards production *(1)*	R&D leading for technical aspects strong VA focus Purchasing evaluated final cost and part availability. Fast proto-typing; Long transition period towards production *(1,6)*	R&D leading for technical aspects including part availability Long pauses between intensive evaluation cycles. Long transition period towards production *(1, 6)*
PDM 4 Promoting standardi-sation and simplifi-cation of designs and parts	9 Hidden specifications 21 Unclear restrictive specification format	Not actively pursued, Achieving functional performance was leading *(9)*	Striving for standard product Result somewhat customised design	R&D and Purchasing strove for standard supplier product halfway through the project. Customised part was the result *(9, 21)*	Partial standardisation pursued Functional problems and chosen concept inhibit simplification and standardisation	Not actively pursued. Achieving functional performance was leading *(9)*	Not actively pursued, customised design	Supplier and Océ strongly focus on simplified design and parts	Not actively pursued

The first activity *__providing information on new products and technologies being developed or already available in supplier markets (PDM 1)__* can be characterised as a scattered process in which both Purchasing and R&D were searching and bringing in information and typically investing time and resources within development projects. Océ spent particular time on important technological areas such as print heads, controllers and power supplies, to research the availability of external technologies and potential suppliers. However, this primarily occurred within the development phase of the project. During some periods of time timely availability and consideration of such information was difficukt due to operational workloads for buyers and R&D people. This increases the risk of longer development phases and longer overall projects. Although specific specialist technical Purchasing/R&D groups exist within Océ to discuss new developments in typical production technologies (e.g. plastic moulding, sheet-metal), new developments in new module suppliers were not structurally monitored. Monitoring efforts were mainly triggered by project-specific requests.

A closely related activity is *the suggestion of alternative suppliers, products and technologies that can result in a higher quality of the final product* (PDM2). A mixed picture emerges from the case studies as to the actual contribution of suggesting alternatives to the improvement of the quality of the final product. Since most of the technology development took place with a development project as the initiator, alternatives were proposed and considered during a project, which required additional search costs and time (optics unit WF1 and SF, PC-based controller, PRU, MSU cases). Two contrasting examples were the power supply and the paper separation assembly case studies. In the first case, the project team had the luxury of being able to consult two preferred suppliers on a future non-compliance problem. In the second case, however, the project team chose a separation technology that due to time pressure prevented Océ later from considering alternative concepts to solve the emergent separation problems and therefore from considering alternative suppliers. Regarding the suggestion of possible second tier suppliers, we expected suppliers to be pro-active and capable of making optimal choices. In many of the multi-technology parts, Océ learnt the importance of choosing a 1st tier supplier that is competent in selecting and building a supply network relevant for the parts and suitable for the role in development. In the MSU case we saw the risk of increased co-ordination costs and responsibility discussions when Océ became strongly involved in the choice of the second tier supplier.

The *evaluation of designed parts in terms of availability, 'makeability', lead-time, quality and costs* (PDM 3) was a critical activity in which optimal trade-offs were not always made. Aspects such as functional performance, durability and reliability received the highest attention, followed by manufacturability and cost aspects. These aspects sometimes seem to be taken into account in a haphazard way. In the heater power supply case, the experienced buyer, R&D engineer and supplier together successfully evaluated the functional performance and solutions to comply with the future norms, while meeting the intermediate milestones. In the PRU case, the R&D engineer had a clear integral focus on optimising product design and taking into account manufacturability issues; this evaluation style worked effectively in the collaboration with Sorto. In other cases these aspects turned into worries for project team members. The problems of hidden specifications in the optics unit cases also shifted the focus in finding solutions to more attention in the assembly procedures. The evaluation of designs was slightly problematic in the MSU case. The Océ project leader and Motio interpreted some of the engineering choices and the rigidity of tests differently in order to achieve the quality and cost targets. The engineer of Motio stated that they were used to engineer in different production series and for different customers, which demanded different durability and quality levels compared to Océ. Cost was less important in these cases. Purchasing's contribution was primarily aimed at evaluating the cost aspects. One of the account buyers of the PRU and MSU pointed out that an important lesson for managing the cost price aspect of design is to agree on a clear cost model with the supplier beforehand, explaining how different elements such as materials, overheads etc are treated. The lack of such a cost model contributed to prolonged discussion rounds on elements of the cost price structure. Part availability and lead-time aspects became major concerns in the optics unit WF1 and SF cases and the PC-based controller case. The shorter product and component life-cycles and higher technological uncertainty in the supplier market therefore required more focused attention, even by higher level management, to address those risks.

Finally, we examine how and in which circumstances Océ was able *to promote the standardisation and simplification of designs and parts* (PDM 4) given a high-level strategy within several R&D disciplines. Although, we observed a general tendency to go for existing production technologies and existing supplier parts, most project teams ended up with customised and Océ-unique specifications (ref: electronics and mechatronics account buyers). In most cases Océ made a trade-off to achieve its minimum technical performance targets at the expense of handling or part costs, and therefore chose for customisation of the supplier part (WF1, SF and WF2). The PC-based controller case is a remarkable case where the switch to a standard PC during the project demonstrated an active pursuit of technologies available in the supplier market. However, at the end of the Moon project it appeared that the PC was customised beyond the combination of standard PC components. Inter-project standardisation did not take fully shape until several years after the start of the first collaboration.

In summary, Océ appears to carry out its product management activities in a well-organised fashion. However, Océ is not always able meet the technical performance and cost price objectives (in an efficient way). Although Océ can come up with information on new and alternative products, technologies and suppliers, the information is not always immediately available and requires in-project search effort. The evaluation of the design appears to be a core project execution activity which contains a significant number of risks that need to be addressed. The analysis suggests that these risks were not anticipated and consequently forced Océ to put more internal effort into the development of the parts than expected. Finally, instead of sticking to off-the-shelf parts, Océ appears to prefer customer-specific designs/specifications, either selecting them from the start or moving towards them during the collaboration. The lack of a continued focus on simplification and standardisation has therefore partially contributed to a slipping cost price and increased the co-ordination costs during and after the projects.

5.4.3 Extent and support of development management activities

In the area of DM, we now analyse how, and the extent to which, Océ provided long-term strategic and operational guidance to development projects, facilitating the typical decisions and activities regarding the management of supplier involvement. In particular, we would expect a clear policy regarding which technologies are to be sourced externally to speed-up the decision-making in development projects because of the reduced time spent on discussing what specific develop-or-buy solution is necessary (PJM 1). Moreover, such a policy can focus the project team on exactly where to pursue standardisation and simplification of the design (PDM 4). The availability and communication of guidelines for supplier involvement and internal departments provides the project team members with instruments to facilitate internal decision-making and communication with suppliers (e.g. PJM 1-8 and PDM 1-4). Table 5.5 provides a summary of each activity and an assessment of the degree of support in each of our individual case studies.

Table 5.5 Description Development Management activities

Development Management Activities	Wide format Printing and Professional Copying and Printing Unit	1 Optics Unit WF1	2 Optics Unit WF 2	3 PC-based Controller	4 Paper separation assy	5 Optics Unit SF	6 Heater Power supply	7 Print Receiving Unit	8 Moving Stapler Unit
		Degree of support to Project and Product Management							
DM –1 Determining Technology In-Outsourcing policy	▪ Basic statement: 'We buy unless...' ▪ Clear in-outsourcing policy regarding specific core copying/printing/ technologies ▪ Large variations at other levels in product architecture and technologies ▪ Relatively large project autonomy and situational decision making in engineering and assembly in outsourcing decisions ▪ Several cross-project initiatives started. Many are not perceived as successful. ▪ Some commodity-specific initiatives are taken. Electronics commodity buy parts / IT technologies	Low	Low	Low	Low	Low	High	Low	Low
DM –2 Formulating policies for the involvement of suppliers in product development	▪ Limited nr of guidelines available ▪ Océ technical design standards were described but not specifically for suppliers. ▪ ISO 9001 process descriptions and guidelines available at Manufacturing and Purchasing	Low	Low	Low	Low	Low	Me-dium	Low	Low
DM –3 Formulating policies for IPDS-related activities of internal departments	▪ A steadily growing number of internal procedures. Some specific routines have emerged, which may not always reflect the official steps in procedures, e.g. supplier selection. ▪ Examples of procedures relating to IPDS activities component Release Process, Purchasing Portfolio used in development projects.	Me-dium	Me-dium	Medium	Me-dium	Me-dium	Me-dium	Me-dium	Medium
DM –4 Communicating policies and procedures internally and externally	▪ Barely ▪ Initially high-level introduction of Océ organisation and project phasing. ▪ Supplier finds procedures and organisation complex	Low	Low	Low	Low	Low	Low	Low	Low

Océ has been attempting to develop a simple *policy regarding the 'in- outsourcing' of technologies* (DM1). In the period during which the optics unit case studies started up, a brief core message regarding in-outsourcing emerged stating, '*Océ buys, unless...*'. This statement underlines the company's general outsourcing trend over the past 20 years across both the Wide Format Printing Systems and Professional Copying and Printing business units. Regarding the development of technologies, Océ has always focused on the internal development of unique copying and printing technologies (e.g. diazo printing, analogue black and white copying toner and process). In the late 1980s, colour copying and digital copying and printing were technological trends that required both business units to make a basic choice and statement regarding Océ's policy on technology in-outsourcing. Such policies were largely developed by R&D, the Corporate Board and the business units. Océ decided to keep the development of its own colour technology and production activities of key components in-house because of their strategic importance. This policy was well-known in all departments. However, when the Star and Beta projects started, a less detailed in-outsourcing policy was available for the technologies enabling the digital transition. The high-level R&D policy to use the technologies available in supplier markets wherever possible, still allowed a broad range of develop-or-buy solutions to be discussed within both project teams. It is therefore fair to state that the policy regarding the in-outsourcing of development, engineering, production and assembly activities of the optics units was largely left to the discretion of the development project itself. The motivation behind Purchasing and R&D's outsourcing of engineering and the assembly of modules is clear. One account buyer (MSU case) views R&D as long being driven by the restricted internal capacity viewpoint and not from a vision to use external supplier expertise as a basis. However, there are differences between internal R&D departments.

A number of initiatives by several departments did aim to influence the extent of outsourcing in product development and assembly activities for products developed for both business units. While the engineering of parts of final copiers and printers were a traditionally in-house R&D activity, the electronics engineering group formulated and implemented a policy for increased outsourcing of development and engineering tasks for parts such as power supplies. This policy was primarily driven by the increasing electronics content in copiers and printers, and the difficulty of keeping the internal knowledge base up-to-date due to fast external technological changes. The policy was well-known among the people involved and reduced the develop-or-buy options (PJM1) to consider, thereby speeding up decision-making in the power supply case. The in-outsourcing policy in the domain of IT hardware and software has evolved dynamically over the last ten years. Given the overall industry trend to develop new machines based on a digital product architecture, the importance of software and related hardware development (e.g. controllers) increased drastically. The PC-based controller technology choice was not clear at the start, but emerged while the Moon project was underway. The policy shift therefore caused the Moon project team to incur extra costs, but also made it a valuable pioneering project that triggered the development of a controller platform policy. Besides these electronic commodity-driven policy shifts, the Mechanical

Engineering and Electronics Engineering R&D departments started the '*Knowledge Industry Clustering*' (KIC) initiative in the mid 1990s, to bring together clusters of local suppliers carrying out product and production engineering activities to ultimately deliver the assemblies. The initiative was heavily subsidised by the government. In return, Océ would be the main contractor and help the region to develop additional knowledge, thus stimulating regional employment and growth. Several development projects, including the Sun project, identified functional modules that had a mechanical and partly electronic content. Connected to the increasing share of external engineering in the total engineering costs was the drive to outsource assembly activities at a higher level. This aspect was increasingly driven by the purchasing department, who, in 1997, started a visible campaign to further push towards the outsourcing of both engineering and assembly activities. Inspired by developments in the car and PC industry, their strategy was founded on a Higher Level System Buying initiative. Since then, this initiative has encountered profound scepticism at different organisational levels within R&D, Manufacturing and Purchasing about the viability of applying a concept that was well-known for its success in mass-consumer industries such as the car and computer industries. The outsourcing of the paper handling modules in the PRU and MSU cases were set-up in the light of both these initiatives. However, given the fact that some of the outsourced tasks were insourced again in both cases, we can conclude that the policy was implemented with mixed success.

If we look at *the formulation of guidelines for supplier involvement and for IPDS-related activities of internal departments (DM 2 and 3)*, we observe that they appear to be insufficiently available and badly communicated with new suppliers, in particular. Although basic information about the organisation was sometimes provided during an initial meeting with a new supplier, this did not prevent some of the misunderstandings between Océ and the supplier, especially during start up. In the PRU, MSU and PC-based controller cases, suppliers themselves indicate that Océ's organisation and its procedures were not very transparent (ref: optics unit, PC-based controller and MSU suppliers). This indicates that insufficient acknowledgement and attention was paid to the learning and adaptation time needed by the supplier and by Océ itself. If we analyse the support of procedures for internal decision-making, we can see that the purchasing department does have a supplier selection process description, and there is a formal procedure to identify and assess buy parts for several well-known parts. However, we detected a deviation from this routine in the actual pattern of decision-making about those parts for which assembly levels and engineering levels were increased or which involved development of new technologies. In general, we can see that Océ's degree of active development and communication of policies and guidelines have not effectively supported development projects with new suppliers. These observations are in line with the findings of a thesis project that was carried out by an internal R&D member. She concludes, '*there is no formal overall R&D policy regarding external technological collaboration known to R&D departmental managers and employees. There is no consistent approach nor guidelines for collaboration with external organisations...*' (Thesis, Brinkman 2003;48). We found that internal guidelines are more advanced than those for collaborations with suppliers. However, supplier selection and determining the extent of supplier involvement are not based on a transparent routine. Such guidelines are apparently not followed or are simply lacking.

5.4.2 Extent and support of Supplier Interface Management activities

We now continue to analyse the extent to which Océ is actively creating a supply base that fits with its general policy to increase supplier involvement. We will also determine whether the project teams in the eight case studies were able to benefit in advance from these efforts. A description of the SIM activities can be found in Table 5.6.

If we consider the first activity, we would expect Océ to be actively *monitoring technological developments* (SIM 1) in such a way that it is able to feed relevant information to projects, in time, so that they may be affected by it or can use it to develop specific parts. This is particularly true when considering alternative technologies and supplier products that are critical for meeting functional requirements and the associated performance targets. It is one of the channels through which future risks for projects can be detected. The analysis of the speed of technological change and the strategic and operational impact for the company, in particular, have proven to be highly critical (PC-based controller). Technological developments were monitored in a variety of ways by both Purchasing and R&D, and differed for various technologies and commodities. Although the heater power supply development benefited from advance efforts to monitor new developments, specific monitoring, such as in supplier market research, appear to have been triggered by the needs of one or more projects already under way or in the near future. The technological developments were usually monitored actively in a number of electronics commodities (e.g. power supplies) via a semi-formal cross-functional team consisting of R&D and Purchasing members. Regulatory developments also had to be monitored since they affected the design of particular parts developed by suppliers. In some cases the monitoring efforts were intensified considerably during a development project (as in the optics unit, PC-based controller, MSU and PRU case studies). We should note that in the period after these case studies were finished, Purchasing and R&D gave the monitoring of print head, controller technologies and relevant suppliers a more permanent character. For example, in the late 1990s an International Purchasing Office (IPO) was established in Asia, which had to monitor specific commodities, the supply market structure and technological developments (ref: IPO buyer). One of the Océ R&D vice-presidents co-ordinated the issues related to the corporate architecture of all Océ machines that required monitoring activities related to IT supplier market developments. Purchasing also assigned a specific buyer to monitor developments in the IT supplier markets, in addition to his account buyer tasks in projects. We can therefore see the initial minimal support at the start of the Moon project, but increased support for follow-up projects. Although a restructuring of the purchasing organisation in 2000 was partially aimed at bringing buyers together around several core functions of a typical copier and printer, in reality there was insufficient monitoring due to high operational workloads for buyers and engineers in on-going development projects.

Table 5.6 Description Supplier Interface Management activities

Management Activities	Wide Format Printing business unit Professional Copying and Printing Unit	1 Optics Unit WF1	2 Optics Unit WF 2	3 PC-based Controller	4 Paper separation	5 Optics Unit SF	6 Power supply	7 Print Recei- ving Unit	8 Moving Stapler Unit
		Degree of support to Project and Product Management							
SIM 1 Monitoring supplier markets for technological developments	▪ Generally project triggered and strongly R&D driven; ▪ Purchasing had 2 specialists for core copying technologies ▪ Monitoring is not permanent driving force due to high operational workload ▪ Some production technologies specialist groups have been active in both Purchasing and R&D. (Rubber, Sheet metal, Plastic moulding) ▪ Separate and joint Purchasing-R&D market research. ▪ Ad-hoc and informal scanning is now supported. by Monitoring function via an International Purchasing Office ▪ R&D scans intentionally regulatory developments Purchasing involvement gradually increased.	Low	Low	Low	Low	Low	High	Low	Low
SIM 2 Pre-selecting suppliers	▪ Approved Supplier List introduced during the 1990s, no emphasis on innovative /engineering capabilities. ▪ R&D developed since mid-1990s a list of preferred suppliers in collaboration with Purchasing for certain electronics commodities ▪ Purchasing categorisation introducing 'Higher Level Systems Buying suppliers'. ▪ IT-hardware and Software partner policy since mid-nineties.	Low	Low	Low	Low	Low	Me-dium	Low	Low
SIM 3 Motivating suppliers	▪ No formal routine; Problem triggered motivation efforts ▪ A variety of occasions and ways of motivation emerge for different commodities, technologies and suppliers	Me-dium	Me-dium	Medium	Low	Me-dium	High	Me-dium	Low
SIM 4 Exploiting suppliers' technical capabilities	▪ Limited ▪ Attempts within certain commodities are made to opt for existing technologies and standard supplier products when designing products, however strong tendency to end up with customer-specific designs and parts.	Low	Low	Low	Low	Low	Low	Low	Low
SIM 5 Evaluating suppliers' development performance	▪ Ad hoc evaluation ▪ Few direct evaluation with suppliers ▪ Some overall project-based evaluation initiatives ▪ Evaluation of supplier development performance is not formalised (part of a procedure) ▪ Limited value of using supplier audit tool as an evaluation tool for product development purposes.	Low	Low	Low	Low	Low	Low	Low	Medium

Regarding the support provided by *pre-selecting suppliers (SIM 2)*, we expected that pre-selected suppliers that were fit for their required role in product development would facilitate the decision-making when planning the collaboration. We found that Océ did not have a large number of pre-selected suppliers fit for the desired increased role of suppliers in product development. In most of the eight case studies the suppliers had not been formally pre-qualified before they were selected, with Optico as the partial exception in the optics unit WF2 case. The most obvious benefit of pre-selecting suppliers was initially only observed in the power supply case, where it enabled the project team to consult a number of suppliers before the project, and to select the most suitable supplier quickly and effectively. The paper handling suppliers with whom Océ had contact were not considered to be suitable for developing customised paper handling modules, such as defined in the PRU and MSU case studies. In most cases, the approved supplier list used in the manufacturing and purchasing organisation did not specifically focus on and support the pre-selection of suppliers for the extensive involvement in product development. Only in recent years have different supplier categorisations emerged in various departments, pointing to efforts to pre-select suppliers for involvement in product development (see Table 5.6).

We observed a variety of efforts by Océ *to influence suppliers to invest in those technological areas where it needs external knowledge and to develop customised parts (SIM3)*. The motivation of suppliers helps to define the area of collaboration and to suggest alternative technologies and parts, and aids the start up of the collaboration (PJM 1,3/ PDM 2). We found more motivating factors than anticipated. For Océ this activity was crucial to realise certain key support technologies. The fact that Océ was able to consult its current supplier of power supplies, persuade them to get involved before the development project had even started, and to invest effort in developing a customised solution, suggests the presence of a motivated supplier. In the optics units WF1 and SF cases, the motivational effort was effective to the extent that Océ managed to find Optico as the only supplier willing to start a customer-specific print head development based on Océ-specific requirements. High level management visits occurred when potential problems were foreseen, to underline the importance that Océ attached to the relationship. In later projects, motivational efforts were focused on aligning the supplier's investments in achieving the technical performance levels that Océ needed for its future projects, and on getting the supplier to increase the number of engineers available for Océ development projects. Other motivational efforts focused on the adoption of compatible 3D CAD systems. Although this was successful in the PRU case, Océ was confronted with the need for extra drawing conversion steps in the MSU case. In the PC-based controller case, it became clear that motivational activities were directed at gaining timely access to supplier design information on PC-components, and the sharing of PC and component roadmaps. This case study demonstrates that identifying the right decision-making level and lobbying at this level became important in creating access and sharing supplier information relevant to Océ. Océ encountered difficulties because its internal organisational units did not always have the power to get (technical) information from other internal organisational departments or suppliers. The reason why some of the motivational efforts succeeded in the projects following the Moon project, was a combination of being an interesting trial customer for the supplier and the top-management lobbying at different organisational levels within the supplier.

In addition to motivating suppliers, we expected Océ to have carefully designated areas in which it adapts its own product design to fit with specific supplier products, parts or materials (SIM4), in order *to exploit the supplier's technical capabilities (SIM4)*. We found that, given its relatively small production series and limited resources, Océ was attempting to create less dependency through applying technologies already available in supplier markets and using standard parts. Although the departmental policy was founded on engineering products based on 'existing production technologies available in the supplier market', several account buyers experienced that this does not guarantee the actual use of a standard design or component. Even within certain commodities that provide high standardisation opportunities at first glance (such as precision motors, power supplies and sensors), a large variety of unique, customised and standard supplier parts are commonly observed in Océ products (Ref: account buyers electro-mechanical/electronics parts). When analysing the standardisation activities in the product management area, we can conclude that the translation of policy into intended standard designs or the adoption of standard components is extremely difficult. A clear example of Océ attempting to apply existing supplier technologies but ending up with non-standard specifications and customised designs was found in the WF2 optics unit and PC-based controller case studies. Technical reasons were often the dominant argument for choosing a non-standard solution. Increasingly, obsoleteness and the availability of specific electronics components is creating a greater awareness and willingness to work on reducing the component variety in order to lower the workload across the R&D, manufacturing, purchasing and service departments. However, co-ordination across projects is difficult in a company which has an internally well-known project-oriented organisation.

Finally, we argued that the *evaluation of the development performance of a supplier (SIM5)* contributes to the capturing of transferable learning experiences which benefit future collaborations. Although the performance of Océ and the suppliers were evaluated in the individual case studies, these evaluations tend to be one-off initiatives. The information/experiences do not appear to be stored, transferred or followed-up in a structured fashion (ref: vice-president manufacturing, vice-president R&D ME). To this day, Océ does not have a structured supplier evaluation process and tools specifically aimed at its role in product development. For example, eight years after the start of the first collaboration with Optico, Océ organised a joint evaluation of each company's strengths and weaknesses. At the end of the collaboration with Motio two evaluation sessions took place which were organised by the Mechanical Engineering R&D department. Although both parties indicated that it helped to communicate and learn from errors and misunderstandings, no real follow-up took place (e.g. improvement plans). During some collaborations, steering committees with representatives from both sides were installed to discuss issues in the relationship or occurring in a specific project. In general, they appear to become active in times of problems but are hard to sustain as a permanent organisational mechanism.

We can conclude that the extent of monitoring of technological developments and pre-selecting suppliers have not been a great support to the PJM and PDM activities within the time frame of the projects[23]. In particular, the provision of information and suggestions of alternative suppliers and technologies and the supplier selection activities have required significant in-project effort. The case studies also suggest that motivating suppliers is considered to be important but only partially successful. However, the activity is not carried out in a structured and co-ordinated way. The evaluation of supplier performance in product development has not been fostering learning and improvement of collaboration for following collaboration periods, partially because it is not embedded in the (formalised) routines of the organisation.

5.5 Enabling conditions for effective supplier involvement management

In this section we examine the support of internal, external and relationship-enabling factors to the effective and efficient management of supplier involvement in the eight case studies. The enablers have been measured by asking questions related to the elements of each enabling factor which have been presented in Chapter 3. The assessment has been Table 5.7 gives an overview of their characteristics.

5.5.1 Internal enablers

We investigated three main types of conditions that facilitate the management of supplier involvement in the four management areas of the framework that can be observed in the internal Océ organisation: (1) the presence of a cross-functional organisation in the purchasing and development departments, (2) the quality of the human resources and (3) the recording and exchange of information.

Firstly, we can observe that Océ does have a type of formal internal purchasing organisation that focuses on the involvement in product development. Several structural arrangements have been implemented that are aimed at enabling the involvement of buyers and manufacturing engineering officially during the engineering phase. An initial purchasing group was formed in which project and account buyer roles were distinguished, serving to maintain both a project and a permanent interface between the supplier and Océ. However, during the cases studied a large number of buyers fulfilled both roles, which can explain the difficulty in freeing up time to spend on supplier market research and pre-selection activities in addition to their operational project tasks. During the engineering phase a formal cross-

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[23] An exception is the PC- based controller case. Océ gradually formed a management steering committee and a joint R&D team to share technological developments to facilitate product planning, testing and standardisation issues.

functional progress team ensured the integral consideration of issues related to manufacturing, purchasing and design.

Table 5.7 Pattern of enabling factors

Enablers	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Internal Enablers	**Optics Unit WF1**	**Optics Unit WF2**	**PC-based Controller**	**Paper Separation Assy**	**Optics Unit SF**	**Power Supply**	**Print Receiving Unit**	**Moving Stapler Unit**
Organisation Purchasing and Development *	**Low** (Increasing)	**Medium**	**Low** (Increasing)	**Medium**	**Medium**	**High**	**Medium**	**Medium**
Human Resource Quality *	**High**	**High**	**High**	**Medium**	**High**	**High**	**High**	**Medium**
Recording and exchange of information	**Low**	**Medium**	**Low**	**Low**	**Low**	**High**	**Medium**	**Low**
External Enablers*								
Supplier Technical Capabilities *	**Low**	**Medium**	**Medium**	**Medium**	**Low**	**High**	**Medium**	**Low**
2nd tier supplier network*	**Medium**	**Medium**	**High**	**Medium**	**Medium**	**High**	**Medium**	**Low**
Relationship Enablers								
Past collaboration experience*	**Low**	**Medium**	**Low**	**High**	**Low**	**High**	**Low**	**Low**
Compatibility in culture /operating style**	**Low** Stable	**Medium** Increasing	**Low** Increasing	**Medium** Stable	**Low** Stable	**High** Stable	**Medium** Increasing	**Medium** Slowly increasing
Mutual trust** (character and competence based trust)	**Medium** Decreasing Competence	**Medium** stable	**Medium** Decreasing character/ competence	**Medium** Decreasing character/ competence	**Medium** Decreasin g competen ce	**High** Stable	**Medium** Decreasing character/ competence	**Medium** Decreasing character/ competence

Low = low level of presence and support
* at start of collaboration

** tendency during collaboration

Some account buyers and manufacturing engineers themselves considered their formal involvement to be too late for complex or larger functions and parts (case 1,3,7,8). The presence of groups specialised in specific production technologies (e.g. plastic moulding, sheet metal, rubber parts) matched the large number of parts present in a copier or printer. Purchasing had also developed expertise in sourcing certain electronics parts. We can clearly see that this structure supported a cross-functional collaboration in, for example, the heater power supply case. However, neither Purchasing nor Manufacturing were always immediately involved in the various decisions concerning the more complex or strategic types of functional units sought in supplier markets (case 1,3,7,8). This was also reflected in the lack of the desired type of suppliers in the supply base at that time. Although the purchasing organisation was reorganised at the end of the 1990s to support the implementation of sourcing functional modules, this adaptation occurred after the case studies had started and was less successful than expected. Another structural characteristic that did not foster cross-functional involvement may be related to the location of the product development team. Whereas R&D members of the project team were co-located, manufacturing engineers and buyers were located in a different building at walking distance. Moreover, purchasing reports to the Director of Manufacturing and Logistics suggest a closer integration with the operations side than with the R&D organisation. On the whole, we note that Océ had recognised the need for cross-functional collaboration during different stages of the development process and had designed a structure and process that should have brought in relevant expertise from different departments. However, this formal structure did not guarantee their effective and timely involvement in the selection process.

In addition to a cross-functional organisation, successful collaborations may be positively influenced by the *quality of internal human resources*. The extent to which the collaborations in the case studies were facilitated by the actual presence of capable human resources varies. Many of the buyers at Océ possessed a significant amount of experience gained internally. Some of them had been working for years in the R&D department. This certainly helped them to understand the 'engineer's language' (cases 4,6,7 and 8). The majority of buyers did not have academic degrees, but most of them had polytechnic degrees and sufficient knowledge to also understand the technical aspects of the parts they were buying (cases 4,6,7 and 8). In recent years junior buyers with academic backgrounds were also hired for purchasing tasks in the IT hardware and software area. In the optics unit WF1 and SF cases, Purchasing still had to start developing knowledge about the technology and the players in this supplier market, and therefore assigned one buyer to the LPH technology domain. During the collaboration in the optics unit cases his experience grew further, allowing Océ to become involved in the WF2 case early on and natural without problems. In the optics unit cases, the quality of R&D development engineers was instrumental in advancing the knowledge on print-head technology, and thus to ensure a successful market introduction. In many cases, there appears to be a commercial and technical role division between the buyer and engineer. In the heater power supply case this worked out fine. Both the buyer and engineer had been working together with the supplier in numerous projects. In the PRU case, the second R&D engineer's valuable engineering background and experience in outsourcing projects strengthened the effectiveness with which the redesign activities and the evaluation of prototype activities between Océ, Sorto and the second tier suppliers were co-ordinated. Moreover, the specific development approach adopted made the supplier feel that he was a contributor to, and joint owner of, the engineering output. One of the issues distilled from the case studies suggests that the team instability on both sides undermined the preservation of experience and an overview of the project on both Océ and the suppliers' sides (cases 3,7 and 8). These fluctuations may have required extra time to be spent on coordinating the development work with this supplier, and resulted in a loss of collaboration history relevant to understand choices made in the past. In the other cases, there is no clear evidence that the specific quality of people influenced the collaboration in a very positive or negative way.

The third internal enabler providing support for effectively organising and managing supplier involvement is argued to come from the way that Océ *records and makes information relevant in developing parts with suppliers available to relevant actors*. Although Océ has several systems for administrating design and specifications, the system infrastructure for management of product data with suppliers was not compatible in some cases, and did not support an efficient communication between Océ and the suppliers (MSU and, to a lesser extent, optics unit cases). In the PRU case, on the other hand, the supplier invested in a compatible CAD system and software that did aid the collaboration during the project. Relevant information regarding suppliers and supply markets was gathered via a variety of channels in the R&D and purchasing departments, but was not recorded in a central database. The integration of supply market information possessed by Purchasing and R&D appeared to depend on project-specific initiatives or when managers decided to discuss certain topics in cross-functional meetings (optics unit SF case). Furthermore, information on performance or capabilities of a supplier or developments in supplier markets were not recorded through information systems or exchanged in a standardised way. While supplier audit data or supplier quality or logistics performance data were recorded, they remained primarily within the manufacturing and purchasing organisation. In addition, the approved supplier list remained largely within the purchasing department, although they have recently put it on the purchasing department's intranet site. Finally, technical information on standard electronics components was kept in a central database within the R&D electronics engineering department. This database did not play a supportive role in any of the case studies, by simplifying or standardising designs or in suggesting alternative technologies or components. In general, Océ's information infrastructure and sharing practices did not appear to offer any substantial support in selecting suppliers or in suggesting alternative suppliers and technologies.

5.5.2 External enablers

We observed that the *suppliers' technical capabilities* did not entirely match with those required for the expected supplier role in development. The presence of appropriate *technical capabilities* enabled Cerel's successful involvement in the heater power supply case. In the PRU case, Sorto possessed the requested production engineering capabilities. It is important to note, however, that its effective use was ultimately made possible by the hands-on problem solving and co-ordination approach of the engineers on both sides. In the optics unit WF1 and SF1, both Océ and Optico found themselves in a situation in which they lacked the relevant knowledge to translate the functional requirements into technical specifications. An important detail was the fact that the supplier's print head was used in a unique fashion that was different from Optico's other customers. In the MSU case, the perceived supplier expertise in motion control and evidence of engineering expertise in different disciplines for other customers were insufficient for a complete design and production engineering according to Océ's performance priorities. In hindsight, Motio considered Océ's engineering targets to be very demanding (ref: supplier engineering project leader) which likely follows from its engineering experience profile related to lower production series. Océ was also not satisfied with Motio's ability to involve second tier suppliers in the production engineering of components and the monitoring and communicating of potential budget overruns. These observations point to the importance of assessing additional non-technical capabilities such as project management capabilities. The optics unit cases clearly demonstrate how the support offered by the 1st tier supplier's supplier network affected the result of the specific collaboration.

5.5.3 Relationship enablers

In the third category of enablers, we note that a number of enablers were particularly dynamic and were often lacking. As such they threaten the realisation of effective collaborations. The first striking condition concerns the low level of collaboration experienced by Océ and its suppliers in four out of the eight case studies. Optico was a new supplier for Océ in two of the three projects, and this resulted in numerous questions and adjustments during the collaboration. In the MSU case, the low level of *collaboration experience* caused problems in the mutual understanding of the development targets and the project approach. This can explain why the co-ordination and the results of the prototype evaluations were unsatisfactory. The relationship already existed in the PRU case, but only in the area of production plastics and metal components. The lack of experience in the engineering and production of a complex module briefly caused problems at the start of the collaboration. The collaboration experience is therefore likely to depend on the experience of the supplier in the relevant aspects of product development, in addition to the number of years the companies have been working together. In the PC-based controller case, the low level of experience also partially explains why various processes were not quickly aligned. In the optics WF2 case, Océ had readjusted their expectations of the supplier's technical capabilities downwards to a more realistic level as a result of experiences in previous collaborations. However, Océ still over-relied on the direct match between a standard supplier product and the achievement of its desired functional performance; this led to redesign activities.

In a number of cases the differences in *culture and operating style* between Océ and its suppliers hindered the communication and co-ordination of development activities. This enabler is slowly developed over time and is related to the amount of collaboration experience. In the heater power supply and paper separation assembly case studies the parties knew each other from previous collaborations. However, in the remaining case studies the supplier was new and also differed in culture and operating style. For example, in the PC-based controller case several years were necessary to understand how the internal organisation and dynamics in Chain-PC's main markets worked. Moreover, it took a long time to resolve the misunderstandings resulting from differences in interpretation of the specifications provided by Océ and of the level of 'customisation' demanded and provided. In the MSU case, adjustments appeared to be necessary, in terms of engineering style and the interpretation of targets and test results. In the PRU case, the assignment of a new Océ engineer resulted in a good fit in operating styles between the engineers on both sides. In the optics unit case, Océ encountered difficulties in its initial communication with Optico. In addition to the cultural and language differences between their Western and Asian cultures, the communication problems also resulted from the unique technical and academic character of the questions that Océ asked. These questions were strongly related to the unique printing technology for which the supplier's optics units were used. Océ's perception was that Optico was not accustomed to these questions. According to the second account buyer, the negative image that (temporarily) emerged was not completely justified, as Optico probably knew more than it was able to effectively communicate in English to Océ. Optico was able to translate knowledge into actions internally, and arrive at the answers in their own trial and error way of working. One of the important habits that emerged during meetings between Océ and Optico representatives was the use of the white board to explain and point out technical aspects (ref: electronics engineers; account buyer 1,2).

If we consider the levels of *mutual trust* in the collaboration, we can see that in the heater power supply case no discussions took place in the project team or by management that questioned the capabilities or behaviour of Cerel. People involved speak highly of Cerel as a collaboration partner based on capabilities demonstrated in the past. Conversely, no specific events were recorded that could point to low levels of trust in Océ as a customer. We therefore conclude that high levels of competence and character-based trust facilitated the collaboration between Océ and Cerel. In contrast, the optics unit cases point to a decreasing level of trust in the supplier's competence when the quality of several prototypes did not meet Océ's expectations. Moreover, Océ was confronted with a second tier supplier whose quality control practices it did not completely trust. In the separation assembly case, character-based and competence-based trust decreased after a large number of functional problems in the field were recorded, and after Océ discovered that the production conditions had been changed by the supplier without immediately informing Océ. The collaboration in the PRU case was affected by both varying levels of competence and character-based trust, despite the good engineering results. First, different perceptions existed at management level regarding the supplier's product and production engineering and sourcing capabilities. What is striking is that a 'negative' collaboration experience and the subsequent termination of the collaboration in another project affected the trust in the supplier's contribution in the Delta project. The continuity of the relationship was then put to the test again by the rather unexpected supplier divestment actions. Besides the decreasing levels of trust, actions from account buyers and R&D engineers also partially restored the competence-based trust. Examples of such actions include organising confrontations with the intermediate and final output of the collaboration (e.g. prototypes), visits to the supplier's manufacturing site and creating opportunities for Océ's and supplier's employees to meet on several occasions during a project.

The issues, problems and disappointing results can also be attributed to the absence or partial presence of the '*supplier's technical capabilities*', '*collaboration experience*', '*compatibility in culture and operating style*' and '*mutual trust*'. This resulted in more time being spent on co-ordinating development activities (PJM execution) and on evaluating product designs (PDM).

In fact, resources were spent on repairing the consequences of decisions taken earlier in the planning stage of the project management area. A stable team interface with the supplier is helpful in new collaborations in order to foster learning. Trust and compatibility in operating style appear to be dynamic conditions that can be improved if they are consciously worked on. To that extent, it appears that the formal structure of arranging early involvement of purchasing and manufacturing representatives is a necessary but insufficient condition to bring in expertise and build commitment in different supplier involvement collaborations.

5.6 Driving conditions for effective supplier involvement management

The question still remains of whether our understanding of the performance and problems in the case studies can be increased by examining any differences in the way activities are carried out, given the specific contextual differences that Océ faced during development. In Chapter 3, we suggested a variety of measures of complexity, novelty and uncertainty that represent characteristics (attributes) of the business unit's environment, the overall development project and the part to be developed.

5.6.1 Business unit driving factors

We assessed the characteristics of the 6 driving factors listed in Table 5.8 at business unit level.

Table 5.8 Business unit level driving factors

Company / Business unit level driving factors	Wide Format Printing business unit	Professional Copying and Printing Business unit
R&D dependence	High	High
Supplier dependence	High > Purchase value 80% of manufacturing cost	High > Purchase value 80% of manufacturing cost
Manufacturing type	Medium-series based production	Medium-series based production
Business unit Size	Medium sized	Medium sized
Market uncertainty	Somewhat increasing competition Cost pressure lower than in other BU	Increasing competition and cost pressure in higher volume segments
Technological uncertainty (Turbulence)	Medium	Medium

As argued in Chapter 3, companies exhibiting high levels of these factors are required to actively execute the policy and guideline developing activities in addition to actively developing and maintaining a supply base for involvement in product development. We note relatively high scores on all dimensions. Given the level of attention Océ pays to, and the coherence of DM and SIM, we can argue that an imbalance exists in both business units between the short and long-term orientation in managing supplier involvement. The policy to increase the level of supplier involvement is not effectively supported by a systematic execution of SIM activities. It allows large project discretion in taking supplier related decisions which may help the project on the short-term but may not effectively support the capability to improve the speed and efficiency in developing new products. An important aspect may also be the relative importance of product technical performance and cost targets that projects within te WFP and the PC&P business unit. Differences in priority setting may trigger the need for different activities in the SIM area that support pre-project stages (monitoring technological developments, supplier pre-selection) and the type of contributions needed from suppliers.

5.6.2 Project driving factors

At the project level, we investigated the impact of project complexity and the degree of project innovation on the need for activities within the Project and Product management area.
Table 5.9 shows the scores of the projects on these dimensions and the overall project performance.

Table 5.9 Project level driving factors

Project level driving factors	Star	Moon	Alpha	Beta	Gamma	Delta
Degree of project complexity	High	High	High	High	Medium	High
Degree of project innovation	Medium-to-High	Medium	Medium	Medium-high	Low-medium	Medium
Overall project performance[24]						
Product Quality	+	+	+	+	-/+	+
Time-To-Market	-/+	-	-	-	-/-	-/-
Product Cost	-/+	-	-	-	-	-
Development Cost	-/+	-/+	-/+	-/+	-	-

If we analyse the differences in complexity of the projects in which the collaborations took place, we may not be able to find significant differences. Since, printers and copiers from Océ are complex by nature, the differences between the projects may not be large enough along that dimension to observe a need for a differentiated approach in terms of both management areas. What appears to be a key factor is the difference between incrementally innovative projects compared to all other more highly innovative projects. Medium and medium-to-high innovative projects such as the Star, Beta and Moon projects (cases 1,2,3 and 5) required information on new technologies and suggestions for alternative suppliers and technologies, due to the development and use of new optics and controller technologies. The development and integration of these technologies and new parts required a large co-ordination development effort. In a less innovative project, a company is likely to reuse more parts from previous product generations. Transferring parts from previous projects clearly reduces the scope at which the project and product management activities need to be carried out. Although the Gamma project started out as a rather low-to-moderately innovative project, in reality, the number of newly developed parts grew during the project, requiring active execution of project and product management activities. However, even slightly more innovative projects (Delta project) exhibited the same need for suggesting alternative suppliers. This need was triggered by the targeted increase in the level of supplier involvement in product engineering. We found, in particular, that the medium to highly innovative projects (practically all projects) in which

[24] The project performance has been measured on a five point scale regarding the degree to which targets have been achieved and has been answered by project leaders and verified with data in project progress reports.

the collaborations took place did not achieve their time and costs targets, and in some cases did not even achieve their initial quality targets. The low scores on project and product management activities therefore suggest that they were not sufficiently actively carried out to address the risks that flow from introducing new elements in the product to be developed.

5.6.3 Relationship driving factors

We continue our analysis of contingent relationships between the need for specific managerial activities and the development risk elements attributed to a specific part. These relationship driving factors are assessed in Table 5.10. We would expect high part complexity, novelty and uncertainty to increase the need for more intensive execution of the project and product management activities. In particular, there is a need for intense communication to co-ordinate development activities between the buyer and supplier. The case studies suggest that the three driving factors must be considered in an integrated way. Those cases that encountered technical problems and higher development costs differed in terms of complexity, but followed a similar pattern of decision-making. Comparing the highly complex and novel optics unit WF1 with the moderately complex and novel MSU, we can see that they both exhibited problems in co-ordinating the development activities. The most striking observation is that Océ had to intensify the co-ordination of development activities both in the collaborations with medium and highly complex parts. Understanding why this was necessary becomes clear when we compare the parts on underlying measures of complexity and novelty. Océ initially underestimated the need for tight co-ordination in cases with high technological uncertainty.

Table 5.10 Relationship driving factors

Relationship driving factors	Optics Unit WF1	Optics Unit WF2	PC-based Controller	Paper Separation Assembly	Optics Unit SF	Power Supply Heater	Print Receiving Unit	Moving Stapler Unit
1. Part development complexity	High	High	Medium	High	High	Medium	Medium	Medium
2. Perceived development risk	High	Medium	Medium	Initially low/ medium	High	Initially High	Low/ medium	Low/ medium
3. Part development novelty	High	Medium	High	Low	High	Low	Medium	Medium
4. Technological uncertainty in supplier market	Me-dium	Medium	High	Medium	High	Low	Low	Low
5. Availability of alternative supply sources	Low	Medium	High	Medium	Low	High	Medium	Medium
6. Degree of new contribution to the functionality of final product	High	High	Low	Medium	Medium	Low	Low	Low

Both in the two highly complex and risky cases (optics units WF1 and SF) and in the cases with lower levels of complexity and risk (PRU, MSU and PC-based controller cases), we observe a similar problematic iteration in the planning and execution of supplier involvement.

If we include other measures of complexity and novelty, we can understand that different characteristics may be at work driving the need for different decisions in the planning and execution activities. The presence of high interaction, unstable functional specifications and high development novelty in developing multi-technology parts requires substantial evaluation of appropriate levels and moments of supplier involvement. The novelty may be present in terms of the functional specifications and the performance demands, but also in the extent to which an existing concept/product is applied in a different way or in a different product architecture (PC-based controller and optics unit WF1 and SF cases). At Océ, insufficient attention was paid to these decisions in the cases that exhibited one or more of these characteristics (optics unit, PRU, MSU and PC-based controller cases). It also seems to be important to implement the right degree of co-ordination to match the level of technical development risk. This match was ultimately found in the PRU case, whereas the long-distance communication was problematic in the optics unit cases, given their high complexity, interaction and novelty. In addition to the complexity, the novelty of different aspects of the technical development may point to the need for additional learning for one or both parties. The right degree of co-ordination and communication facilitating the creation or flow of knowledge therefore becomes critical. The PC-based controller case exhibited a high degree of technological uncertainty in the supplier market (technologies with short component/product life cycles and for which performance levels were rapidly rising); such uncertainty indeed increased the need for tighter co-ordination and information exchange in order to avoid costly redesigns and obsolete parts.

To summarise, we found indications that projects exceeding a critical threshold of complexity and innovativeness required a substantial increase in intensity of project and product management activities. At relationship level, the degree of complexity, novelty and uncertainty are factors that primarily increased the need for more intensive communication to co-ordinate development activities and the exchange of relevant information in the relationship between the buyer and supplier.

5.7 Discussion: determining the critical managerial activities and conditions

This series of case studies was set up to determine whether examining actual collaborations in a high-tech company could reveal the activities and conditions that are critical for achieving short and long-term benefits by involving suppliers. Océ is a large multinational company that, although relatively small compared to its main competitors, has been able to pursue an innovation strategy through developing and marketing new products for many years. Based on the combination of the company's strategy, size, the complex nature of the products it develops and the increasing competitive pressure and technological turbulence, Océ is increasingly under pressure to find new ways of combining internal and external resources that result in successful and sustained new product introductions. Triggered additionally by their limited internal resources, Océ has undertaken a number of initiatives to further increase the role of suppliers in the development and assembly of more complex parts. Based on these circumstances we argued that Océ needs to manage supplier involvement actively through all four management areas.

Our first objective in this chapter was to explain the performance of supplier involvement in terms of capturing the short- and long-term benefits using our analytical framework. The case studies revealed that the heater power supply case achieved the best overall results in terms of meeting the short-term technical performance, and the development time and development cost targets. This was closely followed by the PRU case and the optics unit WF2 case. However, bringing in the long-term benefits, we observed that learning experiences also arose in cases in which the short-term collaboration results were below target. Some collaborations were therefore more valuable than they were initially considered to be. We have been able to partially trace the success in the heater power supply case back to the combination of well-executed project and product management activities, and development and supplier interface management. The main explanation for the performance difference can be found in the way that the collaborations were planned and co-ordinated. The selection of suppliers and the determination of the development 'workload' of suppliers was done in a way that created misalignments in the expected and actual capabilities. As a consequence, technical problems and extra co-ordination and 'repair' costs were incurred. Furthermore, the heater power supply case differed considerably in the overall presence of internal, external and relationship enablers. In the other cases, the cross-functional collaboration in specific decision-making processes was particularly insufficient. An additional explanation is offered by the more extensive execution of development and supplier interface management activities. In the power supply case they provided a clear policy and a set of suppliers with the right capabilities for the type of tasks to be performed in Océ's projects. Finally, we found that guidelines for managing supplier involvement, especially for new suppliers, were insufficiently present or communicated, thus prolonging the adaptation time of the buyer and supplier's organisations.

We can now address the second research question, *'Which sets of managerial activities are critical in achieving the short and long-term collaboration results?'* We argue that the planning activities in the 'PJM' area are critical in successfully anticipating and dealing with possible risks, and can prevent unexpected higher development costs and time. The selection of suppliers and determination of the extent of supplier involvement also appears to affect the risk of technical problems occurring if mismatches in the desired and actual capabilities are introduced in the projects. *Product management* activities are crucial in making the right trade-offs and integrating (standard) supplier technologies in a specific project. They visibly affect the achievement of technical performance targets and the control over the cost price. Timely consideration of alternatives solutions and an integrated evaluation of product design, involving the relevant representatives early on in the project, were important in all of the case studies. In contrast to our initial expectations, product management activities can also result in higher development costs and time. An incorrect evaluation of a design with regards the cost, quality, part availability etc., increases the search for alternative suppliers and co-ordination costs. Failing to create the conditions for implementing the intended standardisation of parts, or designing complex parts, increases the costs of co-ordination during development and increases the field service costs afterwards.

Our analysis of the critical *DM and SIM* activities reveals that a coherent and combined policy guideline and supply base development was most effective for a specific technology category, namely the power supply category. The effort invested in developing a clear in-outsourcing policy for technology and product development activities, and in pre-selecting and motivating suppliers, gave the buyer and engineer a head start in involving the right supplier quickly and effectively. Therefore, DM and SIM, implemented as permanent activities, can indeed contribute to the performance of the collaboration with suppliers. Looking at the influence of the managerial activities on capturing the long-term collaboration benefits, we found that active execution of DM helps to achieve them in two ways. First, it provides a long-term view on the desired internal and external capabilities that need to be built up, allowing a particular specialisation to be developed. It takes away extensive in-project discussions regarding which develop-or-buy solutions to choose. This subsequently allows the buyer and supplier to gain experience in the context of a clear division of tasks. Secondly, it directs the attention towards the type of efforts needed in the SIM area to align technology roadmaps. This benefit may only be significant for specific collaborations concerning technologies/parts with a high strategic impact (critical product differentiator or high cost impact).

We also contended that SIM activities allow potential learning experiences to be transferred to future collaboration episodes, thus contributing to a better match in the capabilities of the buyer and supplier. Although Océ did indicate that it has learnt from its experiences in several cases, and other long-term results have been partially achieved, the benefits did not seem to be captured automatically. Pressures to achieve short-term success and the failure to make them visible create an atmosphere in which the value of longer-term benefits is hardly considered. Lessons learnt from experiences in one collaboration with the same supplier can often not be applied in follow-up collaborations; if the experiences in the current collaboration are negative, this deters follow-up collaborations. Suppliers sense this divided view, which affects their willingness and also their trust. One explanation for this dynamic can be found in the strong project-driven culture which lacks a clear long-term relationship management structure for a large set of suppliers to effectively set out the long-term path of collaboration beyond a project. Such a structure could dampen the negative experiences occurring on the short-term.

In general, we can conclude that Océ's infrastructure for DM and SIM activities was not a strong 'catalyst' in the short-term and project-oriented management of supplier involvement in most of the case studies. They were not sufficiently deployed to create mechanisms that can capture these benefits in future collaborations.

We will now address the third research question, *'what are the critical conditions for effective supplier involvement'*. Our analysis of the external and relationship enabling factors suggested that a partial presence of 'technical and project management capabilities' and 'relevant collaboration experience', 'trust', and a 'compatible culture and operating style' undermine the collaboration process and the achievement of results. Some collaborations that were characterised by changes in their team composition also experienced the need for the increased co-ordination of development activities. Despite the official involvement of different departments, they were not always involved in time for an effective cross-functional assessment of these enabling conditions. This is especially true for the more complex and multi-technology parts. The different expectations of internal departments regarding the supplier contribution during product development could therefore neither be sufficiently verified in advance nor properly communicated to these suppliers. Hence, the collaborations started off with the 'wrong' assumptions. The result was a fragile and dynamic level of internal commitment and trust regarding supplier choices and the role a supplier can play in development and manufacturing.

The quality of human resources, in particular those of R&D engineers, ultimately helped to realise the technical functionality of the part. It appears that the buyers and manufacturing representatives who previously worked in the R&D department were considered to be more credible contributors than outsiders. One of the manufacturing engineers argued that '...the internal experience in the organisation is crucial to be considered a credible partner by R&D. Someone from outside, who may be better qualified, is viewed differently compared to me' (ref: manufacturing engineering unit manager). Océ's information infrastructure and sharing practices did not strongly support different 'PJM' and 'PDM' activities in development projects. Our analysis suggests that the 'PJM' planning activities are critical in verifying external and relationship enablers beforehand, whereas the DM and SIM activities jointly help to maintain and improve these enablers for a future collaboration episode.

Finally, we wanted to understand what circumstances (driving factors) would increase the need for a more active execution of the activities in the different managerial areas. We argued that projects that reach a certain threshold level concerning 'technical complexity' and 'degree of innovation' increase the need for more resources and explicit attention to 'PJM' and 'PDM' activities. Such projects require more advance thinking about how to combine internal and external capabilities, and how to organise the collaboration given its interdependencies and possible lack of particular critical knowledge to realise the innovative elements of the product. We found that the high driving conditions (the degree of interaction of the part with adjacent parts, the novelty of development for both parties, technological uncertainty) primarily influence the need for particular intensive co-ordination mechanisms in order to increase the flow of information exchange between buyer and supplier (e.g. evaluation of part availability).
However, this also requires more attention to be paid to the process of determining the appropriate workload and the actual choice of the co-ordination mechanism.

5.8 Conclusions

In the previous chapter, we ended our case description with an inventory of the various issues. In order to explain the observed collaboration results and these issues we have analysed the specific characteristics of Océ's approach to managing the involvement of a supplier in the development of a part. We conclude that it has not yet developed a sufficient internal capability to pre-select suppliers for involvement in product development accompanied by clearly defined areas of collaboration. Océ does not seem to have developed sufficient routines in preparatory planning and execution within projects in the areas where it wants to increase supplier involvement. The development of such routines is insufficiently supported by an actual cross-functional integration at the start of the project, to identify the different types of collaborations and associated risks. Project teams are confronted with risks as a result of the low presence of external and relationship enablers. If not detected in time, the collaboration can start based on the wrong assumptions and misperceptions, resulting in distracting in-project discussions between different departments. However, relationships with suppliers are also put to the test when they receive signals that they are not good enough. An analysis of the conditions includes the driving factors which require Océ to respond with the appropriate organisational co-ordination mechanisms, to the risk presented by high degrees of innovation, complexity and supply market uncertainty. In the most successful case, the active execution of DM and SIM activities for a specific technology/commodity group had a significant beneficial effect on the efficiency with which the project and product management activities could be carried out. Finally, we can conclude that both managerial areas have the capacity to help achieving specific long-term collaboration results. Motivating activities in advance and during the project are a particularly good way of creating better access to supplier technology.

The case studies at Océ and the application of the IPDS framework have provided an opportunity to unravel the pieces of a complex phenomenon involving behaviour, organisations and technical issues. We have developed new insights and a deeper understanding of the relevant activities related to, and decisions about, the management of supplier involvement. However, some of the findings suggest that the framework was incomplete (i.e. containing only the most critical activities and conditions). In the next chapter we will reflect on the necessary adaptations. We will also examine whether the four management areas really reflect the different managerial areas in which supplier involvement is actually managed.

Chapter 6
Theoretical reflection: revising the analytical framework

'Unclear supplier visions could lead to a situation where ideas from suppliers are not considered as important'
(Nellore, 2001)

In Chapters 2 and 3 we reviewed the literature and developed an adapted model to analyse empirical cases of management of supplier involvement in product development. We then used the framework to analyse eight embedded case studies in a longitudinal case study setting, as described in Chapter 4. Chapter 5 provided us with a variety of insights into which activities are critical and can also explain a visible portion of the performance differences. We have detected the causal patterns (logical connectedness) associated with failing to prevent, or to effectively deal with, some of the problems encountered in the collaborations. In this chapter we use these conclusions as input to reflect on the need for further adaptations to the analytical framework. We therefore discuss the observations made in the concluding sections of Chapter 5, and determine to what extent the results, activities, and enabling and driving conditions need to be omitted, extended, merged or looked at in more detail. We make the adaptations after consulting the literature to find support for, or arguments against, the proposed changes. These adaptations will allow us to further improve and develop the framework, and subsequently apply it to other company contexts. We present a revised analytical framework at the end of the chapter.

6.1 Introduction

In the previous chapter we established that the analytical framework was helpful in providing plausible explanations for the observed supplier involvement results; we did this by analysing the way in which Océ executed different managerial activities and the conditions associated with those activities. The framework for Integrated Product Development and Sourcing (IPDS) was used to partially structure the analysis of the observed performance of supplier involvement. This framework was derived after a literature review resulting in a number of a priori changes to Wynstra's existing framework of purchasing involvement activities, developed in 1998. We examined the results of supplier involvement by taking into account both short-term development performance of a specific collaboration with a supplier and the long-term, strategic benefits. It was argued that the obtainment of these results depends on the active execution of 21 managerial activities in four management areas. During our analysis we developed several new insights into the logic of the different analytical building blocks of the framework. In the following sections we address the need for changes in each of the different building blocks of the analytical framework. Since the framework describes the managerial activities and conditions at a particular level of abstraction, we need to determine whether the model is subject to conceptual flaws or is incomplete. Based on the findings in the case studies at Océ we therefore determine the need for:

(1) reconceptualising the management areas;

(2) further describing in detail existing performance indicators, activities, enablers, and drivers;
(3) adding performance indicators, activities, enablers, and drivers;
(4) omitting performance indicators, activities enablers and drivers;
(5) regrouping performance indicators, activities, enablers and drivers.

To justify particular changes in the framework, each of these five types of operations will be based on a combination of insights gained from our own field research and additional literature. Our objective is to develop a conceptual framework that can be further tested in different contexts within other companies. We start by discussing the need for these operations in the management areas and their underlying activities.

6.2 The critical management areas and activities for managing supplier involvement

The case study analysis and consultation of the literature have led us to make four adaptations. The first adaptation concerns the reduction and integration of the four management areas into two so-called 'management arenas'. Secondly, given the existence of multiple interrelated activities within the current activity descriptions in the original management areas, we have decided to re-label these 'composite activity categories' as 'managerial processes'. Furthermore, the case studies suggest a need to merge and split existing activities, to add new process categories and finally to introduce a certain order in which the activities are carried out. Since the current framework merely lists the activities, we will be able to improve the clarity of the framework by introducing an order that closely matched the actual managerial arenas.

6.2.1 Reconceptualising IPDS managerial areas

By applying the framework for IPDS to the case studies at Océ, we discovered that the Development (DM) and Supplier Interface Management (SIM) area, on the one hand, and the Project (PJM) and Product Management (PDM) area, on the other, take place in two different managerial arenas: the Strategic and the Operational Project Management arenas. We have started to understand that it may not be appropriate to distinguish between four management areas, as this does not sufficiently reflect the empirical reality and is not powerful enough to build explanations for the results of supplier involvement.

The DM and SIM areas were found to be more interrelated than different from each other, in contrast to the argument by Wynstra (1999). They can be viewed as one shared management arena because of their similar long-term orientation and support functions in the management of supplier involvement in projects.

Originally Wynstra conceptually distinguished Project and Product Management because the former contained activities with an organisation and process character, while the latter grouped activities that directly contributed to the improvement of the part design.the case studies, as they share a short-term and project-specific horizon. We argue that the two merged managerial arenas offer managerial controls for balancing two, possibly conflicting, types of objectives when involving suppliers in product development. The first objective is to ensure that the relevant and expected contribution of the supplier is brought into development projects in line with the targets set, resulting in the desired performance in the final project. The second objective is to ensure that the internal organisation and supplier base are prepared for involvement in future projects, and that their capabilities and resources are available and in line with future product and technology needs. Going back to the literature, we found a similar distinction in the work by Monczka (2000). He identifies an 'executional' and 'strategic' context when managing supplier involvement. The executional dimension focuses on the operational planning and execution of collaborations in a development project. Multiple collaborations need to be set up, co-ordinated and evaluated within a development project. If one context is overly dominant, a great deal of effort and resources are needed in the development projects themselves, as we observed in the Océ cases. We argue that the activities in the strategic managerial arena provide strategic direction and operational guidance to development projects. Figure 6.1a shows the proposed redefinition of the management areas.

6.2.2 Introducing managerial processes

When zooming in on the existing managerial activity descriptions, we noticed they are in fact a composite activity category. Most activity descriptions in the original analytical framework consist of multiple underlying activities aimed at managing supplier involvement. These activity descriptions hide their often complex process character. Our first adaptation is to consider such a composite activity category as a *managerial process*. We consider the managerial processes as basic categories of decisions and operational tasks decided on before, during or at the end of a development project. The proposed adaptation enables us to better study the relevant decisions and behaviour related to managing supplier involvement. It simplifies the framework by reducing the number of activities, and at the same time provides more detail about the strongly interrelated underlying activities.

Van de Ven (1992;169-170) discusses three possible conception of studying processes. 'The first view on processes considers a process as an explanation for variance theory. In terms of an input-process-output model, the first definition uses a process logic to explain a causal relationship between observed inputs (independent variables) and outcomes (dependent variables) in a variance theory (Mohr, 1982). In this usage, process is not directly observed....[ ]. '... The second and most frequently used meaning of process is as a category of concepts or variables that refers to actions of individuals or organizations. These categories include for example, communication frequency, work flows, decision making techniques, as well as strategy formulation, implementation, and corporate venturing.

In this usage, process refers to a category of concepts that is distinguished from other categories of concepts. The *third* meaning of process is a sequence of events or activities that describes how things change over time, or that represents an underlying pattern of cognitive transitions by an entity in dealing with an issue. Van de Ven (1992;170) argues that, 'Whereas the second definition of process examines changes in variables over time, the third definition of process takes an historical developmental perspective, and focuses on the sequences of incidents, activities, and stages that unfold over the duration of a central subject's existence. The third meaning adopted in developmental process models, focus on progressions (i.e. the nature, sequence and order) of activities or events that an organizational entity undergoes as it changes over time'. We use for an important part the second process definition. That is, processes such as 'selecting suppliers' and 'co-ordinating development activities with suppliers' are different from enablers and drivers who have a different conceptual role in managing supplier involvement effectively. However, we contend that in order to answer the question how supplier involvement can be effectively managed, processes must be directly observed. This means that events and actions must be studied that will characterise how underlying activities are carried out. Moreover, we have studied the patterns and effects between the managerial processes identified within a given context in a certain of period of time. Although we firmly believe in the power of such perspectives and research methodologies, our aim in this study was not to study the progression (the change in organisational behaviour over time) in a given set of processes over a longer period. We choose to first detect the critical activities and examine how their execution over time (meaning the time period needed for one collaboration in a development project) can help explain the occurrence of certain problems and short and long-term outcomes in the collaboration. In future research the actual organisational development (e.g. maturity in managing supplier involvement may be studied in different periods and focus on change mechanisms (e.g. Evans and Jukes, 2002) focus on such models in the context of a co-development relationship between buyer and supplier).

6.2.3 Defining and redefining managerial processes and underlying activities

We will now introduce the most significant changes based on the integration and addition of activities. The end result is two cycles of managerial processes containing 16 key managerial processes that are presented in Figure 6.1b. The underlying discussion and arguments are given in the following two subsections. All the processes are considered to be contributing to one or more the original processes that have been argued to underlie effective purchasing involvement (see Chapter 3, mobilising, co-ordinating, timing, prioritising and informing). We do not discuss them in these sections but have established the contribution of the managerial processes to the underlying processes as a partial criterion for including new activities.

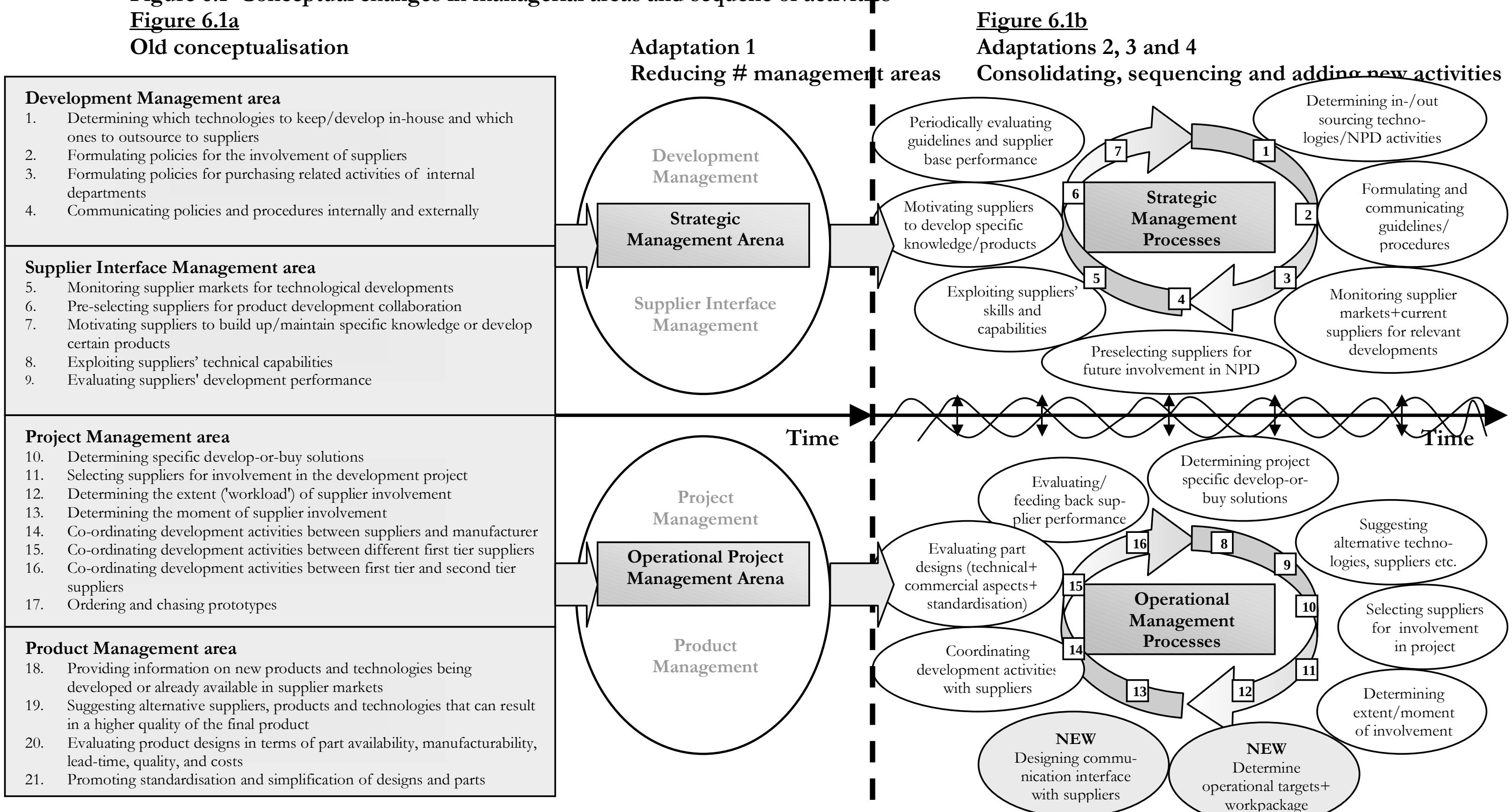
6.2.3.1 Defining, redefining and reordering Strategic Management Processes

The new strategic management arena now contains seven processes in contrast to the nine activities in both the Development Management and Supplier Interface Management areas.

The *seven processes* are considered in a cycle which reflects the planning, executional and evaluative stages in developing policies and the desired supplier base. The order in the Strategic Management Processes as discussed below serves as a reference. Although the processes are, in reality, considered to be executed in a spiralling and interactive conjoint way, this representation of the processes provides a logic that can help us to understand their interrelations (see Figure 6.1b).

In the original framework we considered the starting process for developing and implementing a supplier involvement strategy to be deciding which technologies to keep/develop in-house and which ones to outsource. This is still true, but we now propose to add another activity and to redefine both activities as a new managerial process: *'Determining an in-outsourcing policy regarding technologies and product development activities'* (process 1, Figure 6.1b). A significant amount of the literature has underlined the identification of the core and non-core competencies (Prahalad and Hamel, 1990) as an important starting point for managing a company. The literature on supplier involvement in product development also takes the technology in-outsourcing policy implicitly, and sometimes explicitly, as an important starting point. For example, Monczka et al. (2000) explicitly identify three process steps that together result in an assessment of which external technologies and capabilities are needed now and in the future. The associated analysis and resulting policy support the corporate strategy and provide guidance for lower level decisions in all departments relating to the product development process. At Océ we found that the first step was indeed developing an *in-outsourcing policy*. The core technologies in the case studies were well-defined, however, the policy was framed at a high corporate level. This policy left out a large portfolio of supporting technologies, some of which were new and required a more concrete policy. This raises the question of what the scope of such a policy should be for it to support development projects. If the company provides directions that are too stringent, this limits the flexibility; project teams may need to define relevant areas and the extent of involvement to better suit the specific project design and performance priorities. On the other hand, if the company leaves a wide range of areas and options open to the project without providing any direction, this may result in time-consuming decision-making. Nellore (2001) argues that a common vision needs to be developed and communicated with suppliers, regarding the type of capabilities that are needed from them. These capabilities refer to the skills and knowledge that are needed to carry out particular development tasks associated with these technologies. The successful case studies at Océ and the literature suggest that in-outsourcing of key technologies also involves the range of product development activities that are left to suppliers for the outsourced technology category. We therefore argue that the scope of the in-outsourcing policy for technologies in the current definition of the activity needs to be extended to become a policy for the range of product development activities for a particular commodity or technology. This will provide more guidance, while still leaving sufficient options open for project teams to exert more or less influence on the design.

Figure 6.1 Conceptual changes in managerial areas and sequenc of activities



In addition to policies, we found that a company that actually intends to involve suppliers in product development must *develop and communicate guidelines for managing supplier involvement to all relevant departments and suppliers* (process 2, Fig. 6.1b*)*. We therefore propose to merge the previously separate Development Management activities of formulating and communicating guidelines (activities 2,3 and 4, Fig. 6.1a). Guidelines help people in a complex organisation to organise their work and not to forget elements that they need to analyse beforehand when taking specific decisions about supplier involvement. Procedures and guidelines describe levels of formalisation of specific activities and processes that should increase the efficiency and effectiveness of their decision-making (Mintzberg 1979; Van de Ven, 1985). We have observed that a lack of procedures and guidelines does not necessarily result in ineffective decisions, but does increase the chance of underestimating the risks of involving suppliers.

Guidelines could be particularly helpful to support new suppliers or new people entering the organisation and/or those with little experience. They can help to speed up some phases and aspects of a collaboration with a supplier, or help to get them started. One such guideline could be a kick-off meeting with all relevant people involved at the operational and management level from both the manufacturer and supplier. Other relevant guidelines could be related to the testing procedures and templates for reporting on intermediate budget situations and sharing information about the part costs. This facilitates the co-ordination and communication between both parties. Furthermore, mutually accepted guidelines across different departments help to build commitment and consensus for certain decisions, as the relevant information for decision-making becomes visible. As argued by Wynstra (1999), the roles and responsibilities of different actors in product development are also made explicit. This increases the opportunities for more transparent and effective collaborations between the different internal departments. If they are communicated properly, guidelines can therefore help to create commitment regarding supplier involvement decisions.

Having defined policies and guidelines, a willing and capable supply base must be created and maintained in line with that policy and guidelines. We propose to redefine the current activity (activity 5, Fig. 6.1a), 'Monitoring supplier markets for technological developments into the process' into '*Monitoring supplier markets and individual suppliers for relevant developments*' (process 3, Fig. 6.1b). Based on the Océ case studies and the literature, we found that at least three different types of intelligence-generating activities need to be carried out to support development projects and to identify opportunities and risks. Such intelligence can usually be collected at the level of the supplier market(s), or at the level of the individuals and suppliers currently in the company's supplier base.

One of the first critical activities is *monitoring technological developments* by carrying out 'supply market research' and by meeting key suppliers to discuss their plans or expectations for the future. However, the Océ case studies suggest that the relevant scope of monitoring needs to be broader than the current definition of the activity indicates. The second monitoring activity should be aimed at monitoring the *regulatory developments in the markets of the manufacturer* *and the supplier*. Future legislations and norms appear to have an impact on the relevant pieces designed and supplied by suppliers, and a company must therefore have a monitoring function that can detect and interpret the need for involving suppliers in meeting regulatory norms and standards relating to safety, environment or noise aspects. It is important to note that legislation in supplier markets may not be in line with the norms that apply in the markets that a manufacturer serves. Non-compliance risks can be reduced by being aware of this and by feeding this information into development projects. To meet future requirements regarding safety or environmental norms, it is essential to be able to anticipate these requirements and translate them into relevant parts designed and supplied by suppliers. The third relevant activity suggested by the Océ case studies concerns the *monitoring of the supplier ownership structure and its capability portfolio*. Suppliers who unexpectedly acquire or divest activities may make themselves more or less attractive to a manufacturer. When a supplier is taken over by another company, this introduces uncertainty about the strategic direction of the supplier. Such events can seriously affect the ability or willingness on both sides to further develop a long-term relationship, and can therefore undermine the effective involvement of suppliers in current projects.

The pre-selection of suppliers for involvement in product development (activity 4, Fig. 6.1a) is a key factor in building a capable supply base that can accelerate decision-making regarding supplier selection and the choice of the extent and timing of supplier involvement. Based on the insights from the case studies and previous supplier involvement literature, we now consider the original activity to be a managerial process consisting of three underlying activities (process 4, Fig. 6.1b). Together they help development projects to benefit from capable, pre-selected suppliers. Firstly, the pre-selection involves the pre-qualification of capable suppliers and the compiling of a list of preferred suppliers from which project teams can choose. It provides the gate through which suppliers are screened in terms of their specific capabilities in different areas in product development, and are assessed in terms of various risks for involvement. The literature on supplier selection suggests that the pre-qualification of potential suppliers is an important practice (Van Weele, 1994). Supplier audits are a well-known means of pre-qualifying suppliers. The second underlying activity is the evaluation of the supplier's innovation-related capabilities that are relevant to its envisaged role in future development projects. Innovation-related capabilities are a condition for improving the value offered to the manufacturer in the product development process. These innovation-related capabilities may be measured by the composition and experience of the supplier's engineering department and the supplier's investment in its own R&D. We can argue that 'pre-selecting' can also refer to consulting and involving suppliers outside a development project in developing and partially testing technological concepts and/or parts that can be used for future development projects; this is the third underlying activity. During one of the case studies at Océ, a supplier outside a development project was consulted to work on a particular solution for a future problem that would affect the power supply. Some authors (Handfield, 1999) have pointed to practices by leading companies who have 'advanced technology groups' that work on particular applied technologies and parts that are stored on the shelf for application in future projects. Similarly, Twigg (1998) refers to "*Volkswagen's intention to have all functional parts of new models entirely based on pre-developed components; thus, the supplier will be integrated early to provide pre-developed modules for storage in a "Goal Catalogue' (Sleigh 1993)*". This enables the company to involve suppliers quickly and to reduce some of the technological risks in advance.

Besides pre-selecting suppliers, additional efforts are necessary to secure a long-term alignment of the capabilities that are needed for future projects and that are in line with the in-outsourcing policy. A buyer therefore needs to identify those areas and suppliers in which it needs *to motivate the supplier to build up/maintain specific knowledge or develop certain products or parts* (activity 5, Fig. 6.1a). We consider motivation to be a managerial process (process 5, Fig.6.1b) and we provide further details regarding the scope of the motivation and the organisational mechanisms facilitating the motivation process. Motivating is basically influencing the timing and direction of technology and product development activities. Motivating requires the manufacturer to develop a tactic in which he either communicates challenging cost or technical performance levels (such as tolerance) to the supplier, or defines particular types of modules in combination with future projects for which he will be selected if he meets these targets. A supplier may then be triggered to consider investment in enabling (production) technologies, to find additional second tier suppliers or even to hire additional engineers. In fact, this type of motivation influences the supplier to make more resources available, such as human resources or investments in machines or test equipment, to support further performance improvement in a particular technological area. Motivating also requires a business case to be set down that convinces the supplier that it is worthwhile for him to invest in time and other resources. In other words, a company will be able to successfully motivate if it positions and present itself as an attractive customer. In the literature, technology roadmapping has been discussed as a prominent tool for synchronising manufacturer and supplier planning of technology and product development activities. According to Ragatz et al.(2002; 397) a technology roadmap '*...refers to the set of performance criteria, and undiscovered products and processes an organisation intends to develop and/or manufacture within a specified or unspecified time horizon'*. We consider sessions in which both technology and product roadmaps are discussed and fine-tuned as a useful organisational tool for developing a successful motivating approach.

In addition to developing a motivational approach, we have observed different areas in which companies can *exploit a supplier's technical capabilities* (activity 8, Fig. 6.1a). We propose to identify three underlying activities. We consider these together to be the managerial process 'exploiting suppliers' capabilities and products' (process 5, Figure 6.1b). Firstly, we discovered that an important strategic decision is whether to apply technical standards being developed in supplier markets when designing new products. For example, in the PC-based controller case Océ decided to use a major technical standard in the supplier market (a Windows-based operating system) as the starting point for future controller platform development. Secondly, companies can start using components, modules or concepts already available in supplier markets when designing new products. Finally, companies can use future supplier capabilities as the basis for designing products that can be integrated in different development projects. Providing projects with instructions of which functional areas, standard supplier products or components are to be used, is another example of how development projects can be supported in determining the extent of supplier involvement and in promoting the standardisation of design.

As the last process in the strategic management arena, we propose to identify a process for *evaluating the development performance of the supplier base and current guidelines* (process 7, Fig. 6.1b). We have therefore extended the former activity concerning the evaluation of supplier development performance (activity 9, Fig 6.1a) by distinguishing two activities. First, we argue that the evaluation of development performance is a strategic process that should be conducted at the level of the supplier base, involving multiple suppliers. For example, when a company is in a transition period towards outsourcing more complex systems, it would be helpful to analyse actual collaborations on a larger scale, to see whether they strengthen the desired outsourced capabilities; this would show the company which specific technologies or commodities require improvements. It may be necessary to adjust the composition of the supplier base to bring it in line with the overall in-outsourcing policy. We propose to include the evaluation of current guidelines for managing supplier involvement as the second activity. Experiences are also triggers for updating and improving guidelines to manage collaborations. They represent a means of codifying previous experiences regarding the management of supplier involvement.

The Strategic Management Processes can be carried out using a number of mechanisms and structural arrangements. One such mechanism includes the use of task groups made up of buyer and supplier representatives; the task groups each have a specific purpose such as sharing technology and product roadmaps and component obsolescence information. Task groups co-ordinate across different product development projects and with other, more operational, task groups focusing on service, assembly and logistics issues. Another example that helps the structuring of the relationship is the formation of a permanent steering committee.

6.2.2.2 Defining, redefining and reordering Operational Management Processes

Whereas the aforementioned strategic management processes share their long-term and support focus before and across different projects, the Operational Management Processes are the engine to effectively set up and manage different collaborations within a development project. We propose *nine* redefined managerial processes as opposed to the *twelve* activities grouped in the former Project and Product management areas. Moreover, we introduce a certain chronological order in the processes, because we observed that activities within the PDM area actually occur in conjunction with the activities in the specific planning and execution areas of PJM (see Figure 6.1b). The result is an operational management cycle of processes that reflects the planning, executional and evaluative stages in development projects. Again, this representation is based upon empirical observations that do not exclude the possibility of deviations in terms of the moments at which some of the processes start or in terms of their duration.

The Operational Management cycle starts by determining the project-specific develop-or-buy solution (activity 10, Fig. 6.1a). We consider this activity to be a management process (process 8, Fig. 6.1b) consisting of two specific underlying, related decision-making activities. First, it involves identifying which technological area or areas and building blocks from the product architecture suppliers are going to be involved. The project team then needs to determine the desired extent of supplier involvement. The development of a product involves the definition of a set of product requirements, a product concept with customer functions, and a product architecture. The concept development, design and engineering includes a process of decomposition in terms of the systems and underlying modules, assemblies, etc., which together meet the final customer's requirements. During this trade-off process, the project team defines the boundaries and interfaces of the different building blocks. Project teams often make an implicit or explicit choice about the role they want the suppliers to fulfil in developing the part. Both activities are starting points that have a significant influence on the search for technical solutions and appropriate suppliers.

The next operational process we identify is the need to suggest alternative technologies, components and suppliers who can help to realise the requirements defined for the building blocks (process 9, Figure 6.1.b). We therefore combine two previously separated activities (activity 18 and 19, Fig. 6.1a). The information about new and currently available technologies and components and associated suppliers allows the project team to consider different technological solutions or suppliers. If this process is to improve the quality of decision-making in supplier selection and to determine the extent of supplier involvement, relevant information must be made available to the development team before the actual suppliers have been chosen. This information may come directly from the more permanent monitoring activities regarding technological developments in supplier markets, but needs to made available to the project team. Within the Optics Unit cases we found evidence that technical information on (new) technologies, products and suppliers had to be collected in order to evaluate and trade-off the merits of different possible technologies. This information could also be suggested by pre-selected suppliers themselves. For example, a supplier could suggest alternative components within a larger system after he has been chosen as the supplier and after the development activities have started.

Having investigated the different solutions, a supplier needs to be chosen. We can consider the selection of suppliers for involvement in a development project (activity 11; Fig. 6.1a) as a managerial process that requires careful analysis of the match between the desired capabilities and the available capabilities (process 11, Fig 6.1b). Since of the varying degrees of involvement require different types of capabilities and organisations, we have found that different supplier selection criteria must be explicitly written down and verified beforehand. Furthermore, different representatives from the project team will need to be actively involved in each of the various analyses of the required supplier capabilities. This will enable the buyer to more easily identify the potential risks and will increase the commitment for the final supplier choice.

During or after supplier selection a project team needs to ensure that the desired extent of supplier involvement (activity 12, Fig 6.1a) is truly feasible and with an acceptable risk level; it also needs to determine the moment of supplier involvement (activity 13, Fig 6.1a). We consider the extent and moment of involvement as two separate activities that are sufficiently interrelated to group them in one process category (process 11, Fig. 6.1b). An important point here is that the project team's desired extent of involvement is verified with the supplier's capabilities and is regarded as a realistic starting point. Insufficient attention was paid to this decision in many of the case studies, resulting in a misalignment of expectations and therefore in frustrations later on in the project, in addition to intermediate technical problems. The moment in the overall development process at which a supplier becomes involved is often closely related to the extent of involvement. These decisions are often inextricably linked to each other, due to the interdependence between the degrees of freedom in the part design left for the supplier to fill and the development stage of the overall project when they become involved. However, we recognise Wynstra's argument that the initial contact moments and subsequent intensity of collaboration differ for specific parts (Wynstra, 2000). For example, suppliers of standard parts may still be consulted very early in the process to provide technical information, although no intensive contact may be required for the remainder of the project. In the case studies at Océ we observed the practice of choosing suppliers to become involved during different product development stages. This moment appears to be partially driven by the level of technical risk and the order in which engineers carry out the development of critical functions, but also by the responsibility that a supplier assumes.

The first new process (process 12, Fig. 6.1b) we propose to add to the framework concerns '*jointly setting targets and defining the work package and contractual conditions with suppliers in a project agreement*'. The case studies at Océ provided us with an insight into the difficulties and misunderstandings that occur during particular collaborations. We concluded that problems occur in the communication between the buyer and supplier especially in collaborations with new suppliers or new technologies; this is due to different interpretations of the targets and their relative priorities. Misunderstandings regarding the formulated requirements and specifications can arise because of industry or company-specific ways of working. Moreover, companies tend to have non-formulated expectations regarding the exact role to play in product development, which can result in disappointment during the collaboration. Suppliers may not fully understand what engineering choices are needed given the targets set by the customer. For example, a supplier may not know exactly how rigorous the testing of a part should be because its experience base is based on a different set of demands and trade-offs for other customers. In the literature, different authors point to the importance of establishing the ground rules for the collaboration in ways such as ensuring that there are clearly defined goals, objectives (Bonaccorsi, 1994;142) and responsibilities for the collaboration, which are fully understood by all the parties involved (Farr and Fisher, 1992; Lyons, 1991; Lynch, 1990). Monczka et al. (2000) refers to jointly establishing targets and metrics. Evans and Jukes (2002) concluded in their study based on focus groups and action research that synchronisation of working processes between buyer and supplier in co-development is fundamental to successful co-development. This suggests the importance of a *joint setting of development targets* and spending time on defining and agreeing on the *work package with deliverables* (including their planning) in the early stages of the collaboration. The deliverables should follow from the agreed extent of supplier involvement. Both activities may be encapsulated in a project agreement. In addition to the operational target setting and definition of the work package, some authors have pointed out that a *contract* provides a partial context from which the collaboration can start. The targets can therefore also be included as contractual conditions, however, elements such as the exclusivity of the design, the ownership of the technical documentation package and the risks and benefits of sharing etc. also need to be included. All activities can be crucial in creating the right conditions for co-ordinating the subsequent development activities. In particular, they can help identifying the different phases in development and different commercial scenario's. Evans and Jukes (2002) found in particularly that not only technical but certainly commercial context (e.g. cost price model, volume, criteria for assignment of production) must be clear. This activity facilitates the evaluation of product design and possible changes in the expected production volume. Discussing the scenarios on cost price (one of the targets) beforehand could avoid irritation and prevent the parties from blaming each other at a later date.

The case studies revealed the importance of designing a *clear communication interface* between the buyer and the various tiers of suppliers involved (new process 12, Fig. 6.1b). Designing a communication structure beforehand with counterparts from the relevant departments at the manufacturer and the supplier and indicating who will discuss what issues with whom will help co-ordinate the development activities between all parties involved. At the different managerial levels it is particularly important that the representatives from different departments know what issues to discuss with whom. Authors such as Araujo et al. (1999) and Sobrero and Roberts (2001) clearly discuss the importance of choosing different co-ordination mechanisms for different task characteristics in operational projects. We found that in particular in a first time collaboration or in a collaboration in a new technological area the design of the communication interface extends beyond a specific project team member to the higher management levels. This is certainly true if issues arise during the collaboration that need to be escalated. We have already indicated the benefits of a number of more permanent organisational mechanisms in the strategic management area to support the collaborations in development projects. The design of the communication interface is not limited to the direct collaboration between the manufacturer and first tier supplier. Twigg (1998) argues that for core suppliers of design information, i.e., those that will manage the chain of suppliers, inter-company co-ordination requires the establishment of clear and effective pre-project mechanisms that can be used to develop design phase and manufacturing phase mechanisms. The conscious design of such a communication interface between the manufacturer and various suppliers therefore needs to be identified before actually starting to co-ordinate development activities.

The operational development of the part starts as soon as the critical decisions have been taken and the collaboration has been set up. This requires the actual *co-ordination of the different portions of development between the various first and second tier suppliers* (process 14, Fig. 6.1b). We found the actual co-ordination of development activities to be important in collaborations in which multi-technology and complex parts are developed. This concurs with authors who argue that the interface between suppliers needs to be differentiated depending on different task characteristics (Araujo, et al. 1999; Wynstra and Ten Pierick, 2000; Sobrero and Roberts 2001). One of these frequently cited characteristics is the complexity of the part. We found that a company that involves a new supplier and assigns it a certain minimum level of development responsibility will need to co-ordinate the development activities more closely and more intensely. In other words, it needs more frequent communication between different disciplines and departments to monitor the progress and risks that necessitate technical/commercial trade-offs. Coordination between the first and second tier supplier also requires more careful execution when second tier suppliers are introduced (prescribed) by the manufacturer. The framework is not intended to list which mechanisms should be chosen. However, as we observed in the Océ case studies, different development contexts may require more information-rich communication mediums and co-location to deal with the task interdependencies, or may need to share or develop knowledge jointly (Sobrero and Roberts, 2001).

In addition to the co-ordinating activities the design of the part must also be realised. We propose to integrate two previously separated activities which consisted of evaluating product designs (activity 20, Fig. 6.1a) in terms of promoting the standardisation and simplification of parts (activity 21, Fig. 6.1a). The new process is now called *'evaluating part design regarding commercial and technical aspects and standardisation opportunities'* (process 15, Fig. 6.1b).

We contend that the *evaluation of part design* consists of three activities for which the prototype cycles represent typical evaluation moments. Technical choices during the design and engineering phases require trade-offs that may conflict with commercial targets. Two different groups (activities) of part design aspects need to be evaluated in order to identify and address the risks of failing to meet the targets. The first group contains the 'quality', 'manufacturability' and 'serviceability' aspects, and are of a technical/functional nature. The second group is more focused on evaluating aspects that bear a commercial character. These aspects comprise 'part availability' and 'lead-time of components' and the costs of these parts. Thirdly, the evaluation also involves the identification of opportunities for standardising the components or part designs. We found that the active pursuit of standardisation is related to the strategic policy to use standardly available supplier designs or technologies. Standardisation can take place at different levels and within and across different projects. The truck manufacturer DAF measures the internal and external commonality of parts. Internal commonality describes the reuse of components in different projects, which may have been specifically developed for DAF by a supplier. External commonality reflects the use of off-the-shelf standard supplier parts or products according to the supplier specifications (Besuijen, 2003). The benefits of standardisation are related to cost advantages. Standardisation enables companies to lower their development costs and increase their development speed. They can focus resources on critically differentiating parts of the overall product design. We do not consider promoting simplification of the design to be a separate activity. Simplification is usually taken into account during the evaluation of the design for both commercial and technical aspects. For example, if the cost or serviceability aspects are important, extra attention is paid to simplifying existing designs. Together these three activities affect the final product cost and the ability to introduce the project on time and to deliver enough products to the final customer.

Besides evaluating the part design, we propose that the original activity 'evaluation of the supplier's development performance' also occurs right after a collaboration in a specific development project (process 16, Fig. 1.6b). We consider the first underlying activity to be reviewing how a supplier performed in the project. At Océ such explicitly organised evaluation moments provide additional learning opportunities for future collaboration episodes. It can also make issues in the collaboration that have remained under the surface more explicit and, as a result, can help to streamline future collaborations. As we argued earlier, such experiences can only be exploited if new joint projects are defined in the future. Moreover, the evaluation effort may be more worthwhile if the project team effectively channels the results to the relevant managerial levels, thus serving as input for future supplier selections and possible adaptations to the preferred supplier list. We consider this task to be the second underlying activity in the process of evaluating the development performance of individual suppliers in a project.

6.3 Critical enabling conditions

6.3.1 Reconceptualising the enabling conditions

So far, we have identified two managerial arenas in which two cycles of managerial processes help balancing short-term project-related interests (e.g. meeting the project's targets such as technical performance, cost, development costs and development time) with the creation of the long-term value of supplier involvement (learning experiences, technology roadmap alignment). Managerial processes can be seen as the different gears that need to be powered in order to provide enough propulsion to effectively execute them. The power is partially provided by different conditions that enable a company to plan, execute and evaluate the different collaborations in development projects. Until now we have argued that the enablers in the framework are defined by their location: those that can be found internally in the buyer's organisation, externally in the supplier's organisation and in the relationship between the buyer and supplier. The question is whether each group represents an analytically clear and valid unit of analysis. The internal enabler category groups different conditions that relate to 'structural', 'human resource' and 'information' characteristics capable of supporting or hindering the effective management of supplier involvement. We noticed in our analysis that within the group of internal enablers one subset referred to rather *general* characteristics of the Purchasing and R&D organisation, qualities of the work force or information infrastructure, whereas a smaller subset characterises the project team. As such, the first subset of enablers does not immediately provide room for establishing causal relationships when specific development projects or collaborations are analysed. During our analysis we found that a formal involvement of Purchasing on the project team and the presence of an initial purchasing group specifically focusing on managing supplier involvement in development projects did not guarantee their effective involvement and cross-functional collaboration. This occurred in a number of collaborations that were started or strongly driven by R&D. Therefore their actual involvement should also be measured in the context of a specific development project and collaboration. We can conclude that additional measures are needed to measure whether purchasing and R&D representatives were really effectively collaborating, and whether the people with the right level of technical expertise and education were indeed present.

We propose to split the current internal enabler group up into two sets of enablers at the level of the Purchasing and Product development departmental organisation (organisational level) and of the project team. The first set, labelled *'Business Unit Enablers',* measures the larger organisational context that signals the presence of general human resources in R&D and Purchasing, and an information exchange infrastructure that is conducive to cross-functional decision-making in managing supplier involvement. The second set, labelled *'Project Team Enablers',* allow a closer assessment of the actual availability of the business unit enablers and support to the project team in managing the various collaborations. In this way, we will be better able to derive causal relationships between the impacts of enablers on the outcome of specific collaborations with suppliers. Furthermore, we challenge our initial arguments to distinguish between external and relationship enabling factors. The eight case studies demonstrate that these conditions must be linked to their impact on the collaboration regarding the development of a specific part. General technical capabilities of suppliers are not relevant to analyse but their fit with specific needs in development of the part developed in the collaboration. Similarly, the relationship enablers need to be analysed in terms of their impact on the specific collaboration. We therefore propose to merge the two groups of enabling factors and label the group '*Collaboration Enablers'*.

These adaptations will make the categories less diffuse and result in a more precise measurement of relevant underlying factors. Table 6.1 provides an overview of the proposed changes regarding the internal enabling factors. We will discuss the rationale for each enabler based on the case evidence and support in the literature.

Table 6.1 New conceptualisation and operationalisation of enablers

	Business Unit enablers	Project Team enablers	Collaboration enablers
New level of analysis	Organisational level	Project level	Collaboration level
	1.Cross-functional orientation Purchasing and R&D (Org)	**1. Cross –functional Orientation R&D-Purchasing-project (team)**	**1. Supplier Capabilities**
	a. Fit in knowledge and specialisation Purchasing and R&D department	a. Early involvement of Purchasing representatives in PT	a. Technical capabilities
	b. presence of initial purchasing organisation	b. Extensive involvement buyers in PT	b. Supplier Project Management capabilities
	c. formal representation purchasing on project team		c. Supplier costing capabilities
	2. Human Resource Qualities (Org)	**2. Human Resource Qualities – (team)**	**2. Relevant Collaboration experience**
	a. Educational level organisation	a. Educational level team	**3. Compatibility in culture and operating style**
	b. Experience-organisation	b. Experience-team	**4. Mutual trust/commitment**
	c. Pro-activeness organisation	c. Development Team stability	
		3. Credibility-(team)	
	3. Recording and Availability Info (Org.)	**4. Recording and Availability Info (team_**	

6.3.2 Defining and redefining critical enablers

Cross-functional organisation purchasing and development

To set up different collaborations and to trade off possible conflicting requirements when developing the parts, you need an organisation that can bringing in relevant knowledge from different departments. We argue that the collaboration between Purchasing and R&D is therefore a critical enabler. A company can take several structural measures to stimulate such a collaboration.

We argued that the way expertise and knowledge of the purchasing department are organised vis-a-vis the R&D organisation indicates its orientation towards involvement in the product development process and the R&D organisation. Our case study analysis confirmed that the initial presence of a purchasing group besides an operational group in the overall purchasing departments allows more focused attention to decisions and contributions in the earlier product development stages. A symmetrical R&D and Purchasing knowledge base that reflects the organisation of knowledge around technologies and parts to be developed and outsourced also appears to be conducive to higher cross-functional collaboration. Formalised involvement and team membership of buyers are structural measures that certainly increase the chances of cross-functional collaboration in various operational management processes. We argue that although such a characterisation may officially include the early and extensive involvement of buyers within the project team, this needs to be verified in reality when analysing collaborations for a specific project. The actual picture for a specific development may reveal that such cross-functional collaboration is not taking place.

Quality of human resources

After analysing the case study data we concluded that effective management of supplier involvement is conditioned by the quality of the human resources involved in the different managerial activities. Whereas the original enabling factor was primarily focused on the qualities of the buyers involved, we found evidence that the qualities of the R&D people involved also matter in relation to their ability to carry out the different managerial activities. Since these qualities affect the way the buyer and engineers involved may (jointly) carry out the operational management processes, we need to identify a double set of qualities for both actors. Originally the following factors were considered to be critical conditions for the effective management of supplier involvement: (1) the type of previous experience, (2) the type and level of training/education, (3) the degree of technical expertise, (4) the degree of pro-activeness and (4) capabilities as perceived by others (credibility). With regards to these human resource qualities, we argue that there is a difference between these qualities being available in the total organisation and them being available in the development team to support the various collaborations.We therefore propose to introduce similar variables but adjusted to the their presence in the project team and to measure these variables for R&D department and representatives. We discuss them in the following paragraph.

If we consider the importance of the *educational level* of employees, Anklesaria and Burt (1987: 12) and Atuahene Gima (1995: 220-221) argued that the ability of buyers to bring forward supplier related issues in the project team is positively influenced by a polytechnic, MBA or university degree. We can therefore argue that a higher educational degree fosters joint collaboration, and in particular the setting up of collaborations and understanding the different trade-offs. We contend that finding counterparts with similar educational levels is more beneficial than having only one buyer with a higher educational degree. Again, both a general measure of educational levels of members of both purchasing and R&D departments for the overall organisation and a specific measure regarding the actual presence of high educational levels in the project team is desirable.

Experience can be measured by the variety of internal experiences that actors in Purchasing and R&D have gained in different departments. In the case studies we observed that some former R&D employees had moved to the Purchasing department. This could definitely help to increase the mutual understanding regarding the 'technical language'. Conversely, a move from Purchasing to R&D may also be helpful to the increase the mutual understanding of different aspects and interests. Moves to other departments would also increase the ability of the buyers and R&D employees to understand different processes and trade-offs that may affect their work. A move to a different department can also neutralise the traditional status differences between R&D and other departments (Leonard-Barton, 1992). We therefore want to measure, at company level, how common job-rotations to other departments is among both Purchasing and R&D employees. In addition, the experience of the Purchasing and R&D representatives may also include their relevant commercial and technical experience gained in jobs outside the company. Commercial experience based on value analysis and value engineering experience increases the joint consideration of trade-offs without the technical myopia that guides design and engineering activities. It could also create smoother communications between buyers and engineers. In a similar vein, purchasers may be more able to get involved in the development process if they possess technical experience and understand technologies to the extent that they can suggest alternatives (i.e., they understand the cost-performance trade-offs). A company can strengthen the presence of such qualities by using the commercial and technical experience as joint selection criteria when hiring Purchasing and R&D employees. Although their policy may be to evaluate buyers and R&D employees on these types of experience, the development team might still not include suitable people. We therefore need to determine whether the purchasing and R&D members of the development team have previously changed departments and whether they possess the relevant technical and commercial experience.

A third human resource quality factor is the *presence of a pro-active atmosphere* that strengthens internal collaboration. Focusing on two relevant groups of actors, Purchasing and R&D employees, their attitude and actions to pro-actively contact their counterparts and offer help without being asked helps to foster cross-functional collaboration in important decision-making processes.

Whether buyers are involved in planning and executional processes depends on the *buyer's credibility,* the fourth human resource quality factor. In other words, a buyer's involvement dependents on the perception of other team members concerning their ability to make a useful contribution. Dowlatshahi (1992) already pointed out that buyers may not be involved because they are not perceived as credible contributors during the development projects. The extent to which this credibility is present can be measured by the degree to which both R&D and Purchasing representatives accepted suggestions from each other in their own natural areas of responsibility.

Based on the case study data, we observed that the costs of supplier involvement and the ability to learn between two organisations are undermined by an unstable development team composition. Katz (1982), Lynn and Reilly (2000) and Akgün and Lynn (2002) argued that *team stability* was an important factor that discriminates between successful and unsuccessful development projects. Team stability fosters knowledge accumulation. We can therefore argue that such stability also has a positive impact when collaborating with suppliers. At Océ we observed that some misunderstandings and differences arose in those collaborations where R&D engineers and buyers were changed during the collaboration. The quality of the evaluation of the design and the co-ordination of development activities may particularly suffer if people enter and leave the team prematurely. Knowledge about earlier discussions and decisions or events important in the collaboration history may be lost when new people step in during a specific project unless a thorough transfer of agreements and events from the past takes place.

Recording and exchange of information

Up until now the third enabler has focused on the infrastructure that captures, stores and makes information available on potential suppliers and current suppliers and their performance. It appears that the availability of intelligence (supplier development performance and capability profiles) can be facilitated if it is not only accessible in a verbal way but is captured in a central place in a digital form and is actively shared and used in project teams.

Another important type of information regards the management of design-related information and its exchange between the buyer and supplier during and after development. We specifically observed that the incompatibility of CAD and/or Product Data Management systems between the buyer and supplier can result in extra, inefficient transformation steps to incorporate design changes and to manage drawing versions. This adds to co-ordinating costs and increases possible error margins. Finally, having standard component bases and keeping them up-to-date can be an important facilitator in supporting the standardisation of part design. Again, the presence of an infrastructure does not mean that it is directly available or used in the project team. We therefore argue that this enabler be assessed for the whole organisation and specifically within the project team.

External enablers

Until now we have considered the *technical capabilities of the supplier* to be a condition for effective involvement. The importance of this factor has also been underlined in the literature (Wasti and Liker, 1997; Hartley et al., 1994). The case studies pointed to a need for an additional underlying measure. It appeared to be important that suppliers were able to understand the requirements of the part and possibly its application in the customer's product (Optics Unit, PC-based controller and MSU case). In many of the new collaborations that Océ started, there was a recurrent pattern of suppliers who did not immediately understand the technical requirements despite a first apparent match on their technical expertise and the products developed and manufactured for other customers. If this aspect is not present, then technical capabilities that can be 'objectively' determined may not be used to their full potential in the development of the specific part. Besides technical capabilities, we found project management capabilities to be important for collaborations with suppliers concerning multi-technology products and some degree of involvement. Twigg (1998:512) argues that in collaborations, '…*where product development is required, system integrators (read: first tier suppliers) are assuming major responsibility to control/manage the project management process with indirect suppliers. It is this transfer of project management responsibility that will probably be a key focus for effective design chain management, if vehicle manufacturers are willing to devolve these duties*'.

Davies and Brady (2000:938) define project management activities as 'integrating organisational functions', 'purchasing resources inside and outside the company', 'managing and re-allocating resources through the project life cycle using milestones and deadlines' and 'working in a team basis and using project management tools (PERT, concurrent engineering)'. It is essential to assess such capabilities of a first tier supplier if its tasks resemble that of a project within the supplier's organisation itself. For example, a single component supplier may not need such extensive project management tools, given its late involvement, low interdependency between tasks and its limited supply base. Moreover, a supplier's capability may consist of meeting the target cost set for the part. A manufacturer needs to verify how thoroughly suppliers actually understand the commercial requirements of the project. This also means an understanding of being able to undertake actions to reduce cost drivers relevant for the specific customer. In one industry the avoidance of service-related calls may require specific emphasis, while in another more attention may be required to reducing the weight through using alternative materials. If a supplier understands that designing-in a more durable part is more cost effective than a part with a lower cost price, then he has partially demonstrated his costing capabilities.

Relationship enablers

The case studies have underlined that capabilities can be accessed better, and the understanding at personal level between the counterparts can improve, when the parties have built up a history of collaboration. Until now many studies have assessed the *collaboration experience* in terms of the length of the previous relationship (Nazli-Wasti and Liker, 1997). The cases at Océ suggest that experience is gained through the number of collaboration episodes or projects it is involved in. Furthermore, although the relationship may already have existed for some time, the previous experience needs to be relevant for the level of involvement which both the manufacturer and supplier agree to. Therefore, despite the length of the relationship, its previous experience in the production of parts for this particular customer may be low and represent a potential risk for successful collaboration. We argue that collaboration experience must be relevant to the current intended collaboration. Furthermore, collaboration is also fostered by creating a compatible culture and operating style between the customer and supplier. In the case studies we found several indications that incompatible *culture and operating styles* resulted in misunderstandings and high co-ordination costs to manage the collaboration. A number of national and professional cultural differences (Hofstede, 1991; Ulijn, 1999; Trompenaars and Hampden-Turner, 1999) may have affected the way different actors from the buyer and supplier understood each other and carried out the tasks. Expectations are strongly formed and affected by experience, by corporate and personal values and by an education that facilitates or hinders communication. We consider this enabler to be a factor that helps or inhibits a fast adaptation to each other's way of communication and decision-making. In a similar vein, we came across the role of mutual trust as a cause and result of unexpected problems encountered during a particular collaboration and in a relationship with a supplier in general. Increasing trust in the capabilities and the consistency and reliability of the supplier's behaviour generally supports the collaboration; it speeds up the collaboration by preventing in-project discussions. A high level of trust results in a higher commitment of the actors to support a particular collaboration, which also allows long-term planning with a supplier to take place for the involvement in future projects.

6.4 Critical driving conditions

When considering the conditions that affect the need for processes in the strategic or the operational project management arena, we found that the currently identified drivers need to be maintained. We propose a similar adaptation to the units of analysis as proposed in the enablers section: business unit drivers, project drivers and collaboration drivers.

For the *business unit drivers*, we found that the need for the long-term and strategic processes is indeed high and concurs with high scores on R&D and Supplier dependency, Business unit size and Production complexity. Moreover, the newly introduced driver, 'technological uncertainty' appears to strongly determine whether a company should heavily invest to all of the processes in the strategic management area. Océ needs to carefully monitor available technologies and determine the ways it further develops them internally or externally. We still consider 'degree of project innovation' and 'complexity of a development project' in terms of project size to be relevant *project driving factors*. What still needs to be examined in greater depth is the optimal pattern of processes for effectively managing a portfolio of suppliers. We initially distinguished a set of driving factors that referred to the overall relationship with a supplier. We now argue that the structuring and management of the collaboration is driven by uncertainty, complexity and novelty factors that are present in a specific collaboration episode in a project. In other words, the term 'collaboration driving factors' is more appropriate.

6.5 Reflection on the measurement of supplier involvement results

A last area to reflect on is the actual effects of the managerial processes, which we currently analyse in terms of the short and long-term results of supplier involvement. The introduction of short-term and long-term performance dimensions has enabled us to start building an explanation by analysing individual managerial activities and conditions for supplier involvement. They have also provided us with an insight into whether the current indicators measure all the relevant areas or need adaptations. We will now discuss these insights.

The relevance of the performance indicators grouped under *short-term collaboration* has not really changed. Océ did take into account the technical performance, product cost and the resources and time needed for completion of the development at project level. These performance indicators can therefore be used at the individual collaboration level as well. Although elements such as 'norm costs' and 'tooling costs' are relevant in some collaborations and are less relevant in others, we propose to continue to measure four main performance dimensions. Three issues arose when assessing the performance of supplier involvement. The first issue is related to the relative importance of the performance targets such as cost, development costs, time and quality. A bad performance in an indicator that is considered to be less important may sooth the overall judgement of the supplier performance. Secondly, during the research it was difficult to establish an objective measurement of collaboration success. For example, we considered comparing the performance to similar parts in the past or relative to parts from competitive machines. At Océ such measurements were hardly feasible. The next best way of measuring collaboration results may therefore be to measure the performance in terms of the targets set by the project team itself compared to the actual outcome. Nevertheless, in Chapter 4 we already warned about the reliability of the targets. Were the targets realistic? Without being specialists in the particular technological area, we chose to rely on the targets set by the subjects being studied. Thirdly, we noticed that in the case studies it is very difficult to establish a direct relationship between the performance of the overall project and the results of the individual collaborations. We saw that various projects were lagging behind in time, but this delay was not directly caused by suppliers. In other words, other events or characteristics may also slow down the overall planning. At the same time we noted in the case studies at Océ that the deviations in the actual-to-target performance concerning development and product cost were certainly affected by the higher engineering hours and cost price achieved in the individual collaborations. However, we need to investigate this in a larger sample to see how strong the causal relationship is between the extent of executing the managerial process cycles and the observed project performance.

In the case studies we found that paying attention to the potential long-term benefits of involving suppliers, instead of simply focusing on the operational performance in a specific project, can give a new perspective on the potential value of continuing working with a particular supplier, even if the initial performance was below target. Four types of long-term collaboration benefits have been considered up until now. We first argued that collaboration episodes provide an opportunity for learning, resulting in a *more efficient and effective future collaboration*. A more efficient future collaboration has a time and a resource component. By learning from each other's ways of working and better understanding how to interpret targets, fewer engineering hours are needed and faster development can take place. A more effective future collaboration implies that the output of the collaboration reaches higher performance levels with regards the technical and cost performance. For example, learning about design trade-offs that are important for the customer can improve the design next time around. Learning about the true design and manufacturing capabilities may result in a more tailored, demarcated involvement domain that enables a more effective design contribution. Furthermore, if a supplier understands what trade-off between a part cost and lifecycle costs the customer expects him to make, it can increase its control over the cost price by starting earlier discussions with its own supply base to discuss the risks of component obsolescence and can perhaps suggest higher performing components. All these items refer to both the expected improvement in efficiency and effectiveness on the buyer and supplier side. If we look at the second long-term supplier performance indicator, we have observed that *technology roadmap alignment* is indeed a crucial objective in specific technological areas. The alignment consists of synchronising the planning and investing in the relevant technological areas or products of interest. Consider those technologies which are subject to high uncertainty and can be characterised as high-velocity environments (Eisenhardt and Tabrizi, 1995); integration of such parts with the company's own technology and product roadmap would be supported by a synchronised and up-to-date planning of future technological changes in the supply market. Furthermore, alignment of roadmaps in terms of the investment in relevant technological areas and performance levels needed in the future substantially helps to influence the external resource base and to share investment risks. We observed that such a result requires management processes with a long-term perspective. Alignment only bears visible fruit after multiple finished projects and a periodic communication and exchange of information. We therefore suggest keeping the achievement of a 'better alignment of technology roadmaps between the supplier and the business unit' as a key long-term performance indicator. *Improved access to suppliers' knowledge* refers to the increased willingness and ability of the supplier to develop and make this knowledge available to the customer. We observed that the growing mutual dependence in the optics unit case allowed Océ to ask for more specific technological improvement and ultimately to get more engineering resources allocated to the relationship. We consider the *Economies of Scope/learning* to be the final long-term benefit of collaborating with suppliers in product development. Sobrero and Roberts (2001) have suggested that a particular collaboration can provide broader benefits than the specific collaboration alone. The creation of knowledge and transfer of technical concepts or solutions to future projects may be a specific objective to pursue. We consider this a benefit that can be steered at strategic level by indicating and co-ordinating where and how existing supplier solutions and resources can be used in future projects.

6.6 Further testing of the revised framework

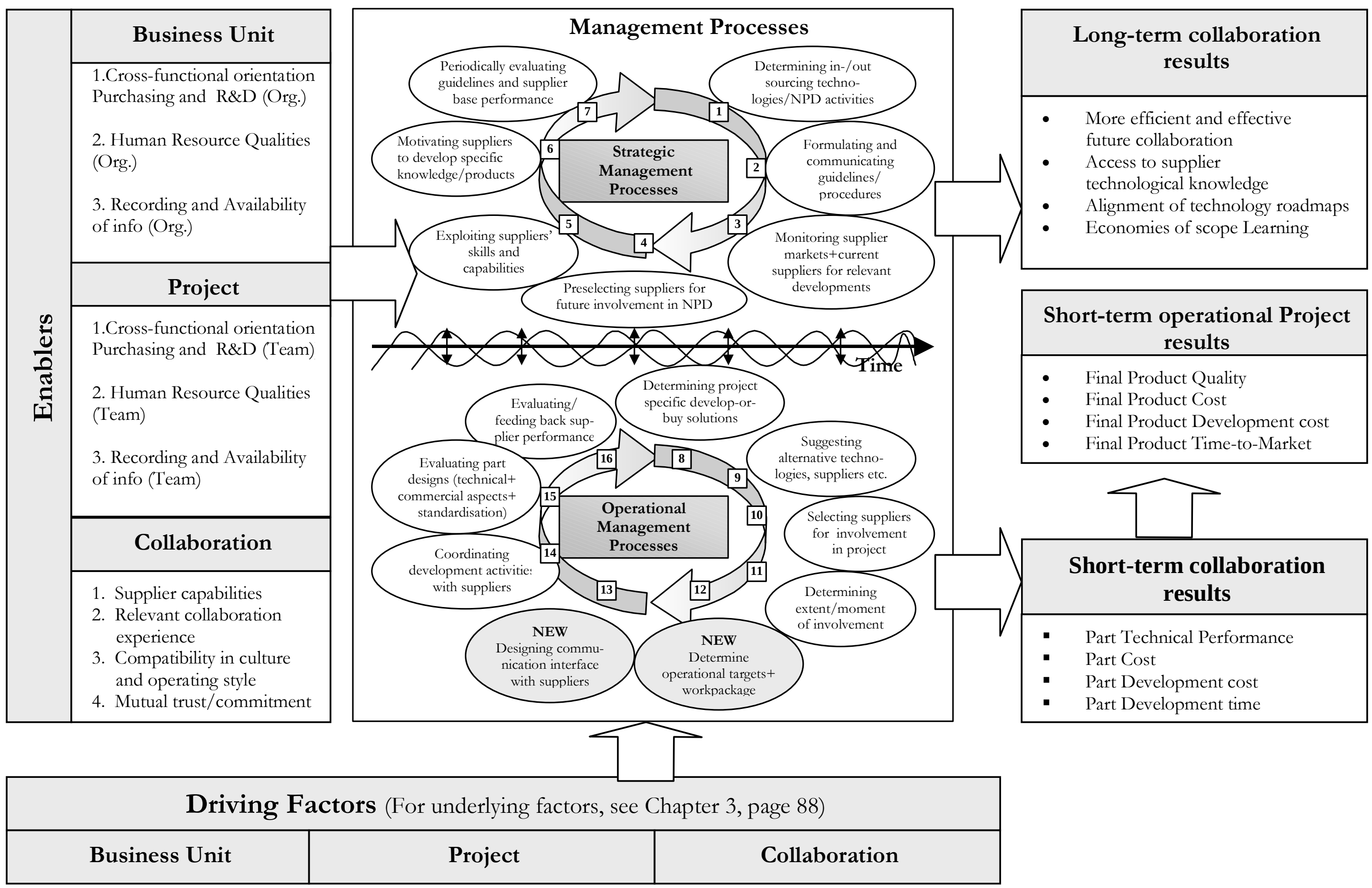
We have been able to partially identify the critical activities and conditions that enable us to explain supplier involvement performance. The findings indicate the need for adaptations of the framework that will affect the conceptualisation and definition of activities and conditions in our initial IPDS framework. In particular, we argue that supplier involvement is managed in two basic arenas: the project and strategic arena. In these arenas, two process cycles form the engines that regulate the balance between trying to achieve short and long-term supplier results. Moreover, we have proposed strengthening the framework by introducing a chronological order in the processes aimed at managing supplier involvement. The order is based on the planning, executing and evaluating processes (learning) that are needed to manage collaborations with suppliers in development projects and at a strategic level.

The case study analysis suggested that most critical *processes* were related to the selection of suppliers and determining the specific supplier role in, and workload during, development. Moreover, companies can substantially accelerate and improve the results of supplier involvement if they pre-select suppliers and carefully determine where to use existing supplier solutions and capabilities, and if they actively monitor supplier markets and individual suppliers. We also argued that an organisation must create the *conditions* that enable the effective management of supplier involvement. It starts with the overall business unit organisation ensuring that the project teams benefit and that individual collaborations are supported. We found that these enablers differ in organisational scope. The business unit enablers measure the basic company infrastructure and human resources that enable a proper cross-functional decision-making and execution of the managerial processes. The project team enablers then ensure that the business unit enablers are in fact available and are supporting a specific project with different collaborations. Finally, the collaboration enablers form the conditions for effective supplier involvement that are most directly related to a specific collaboration. The second category of conditions concerns the *driving factors*. Analysis of these contextual factors helps us to determine whether specific processes need to be more actively executed to effectively deal with the sources of complexity, risk or uncertainty. We found some preliminary indications that complex and innovative projects certainly require highly active execution of most of the operational management processes. If we analyse the sources of risk, uncertainty and complexity associated with a specific collaboration we find more indications for particular choices in terms of the communication interface and the type of co-ordination mechanisms to be used when collaborating. These insights have been summarised in the revised conceptual framework depicted in Figure 6.2.

However, several questions remain unanswered. We need to determine whether this conceptualisation and the managerial activities are sufficiently valid. By distinguishing between three distinct levels of enabling and driving factors, we are left with the question of whether these factors are not in fact related to subsets of the processes in our framework. We have to be careful in making such inferences and conceptual changes without having examined them further in additional empirical case studies. We have to examine to what extent the level of execution of both managerial process cycles affect the achievement of short and long-term objectives. What is certain is that we need to identify those conditions that most strongly affect the short and long-term collaboration results. Finally, we still need to determine how the revised analytical framework can be used as a reference model for diagnosing and improving the processes for managing supplier involvement.

To address these remaining questions we therefore carried out more empirical research. The first initiative consists of a series of case studies on supplier involvement in eight development projects at four companies operating in different industries. The initiative serves two main purposes. Firstly, we test the revised framework in different company and project contexts and compare the results on the managerial processes and conditions with those observed at Océ.

Figure 6.2 Revised framework for Integrated Product Development and Sourcing



Secondly, we develop a self-diagnosis instrument concerning the management of supplier involvement in product development based on the combined case study insights. The methodology and results related to these case studies are presented in Chapter 7. The second initiative consists of an action research project at Océ in which we aim to develop practical guidelines for one of the key managerial processes in the framework. The adopted methodology and results obtained are presented and discussed in Chapter 8.

6.7 Conclusions

In this chapter we have analysed the need to adapt the analytical framework based on our findings in the case studies and a review of relevant literature. Based on our empirical analysis and further analysis of the model developed by Monczka (2000), we contend that supplier involvement must be managed within two important managerial arenas: the project and the strategic arena. The processes that are carried out to manage supplier involvement within the context of a specific development project are called the Operational Management Processes. The processes carried out with an inter-project and long-term focus are called Strategic Management Processes. They focus on preparing the supply base and creating the conditions for future projects to find the external suppliers with the requisite capabilities and to collaborate with them in an appropriate way. Strategic Management Processes are hypothesised to have two types of effects: they can give advance support to the more effective and efficient execution of Operational Management Processes, thus indirectly improving short-term supplier results and, secondly, they can contribute directly to achieving long-term supplier results. These processes are depicted as cycles reflecting the interrelated but different managerial arenas in which supplier involvement must be managed in order to balance the achievement of two different sets of short and long-term collaboration objectives. A set of 16 key managerial processes have been identified in the adapted framework, each with a varying number of underlying relevant activities.

We also argued that the way the conditions for effective supplier involvement had been conceptualised, as internal, external and relationship enablers, is no longer appropriate. As a result of the presence of enabling factors at the overall organisational level and the project team level and given the connection between external and collaboration enablers, we propose to split up the internal enablers into 'Business Unit Enablers' and 'Project Team Enablers' and merge the external and relationship enablers into 'Collaboration Enablers'. In the next two chapters we will address the remaining questions regarding the validity of the revised framework in different industry, company and project contexts where companies are starting to involve suppliers in product development. We also aim to create more concrete guidelines for using the framework as a self diagnosis instrument and for improving a number of critical managerial processes. In Chapter 9 we give a final integrated reflection of the results of the different research methods used and present the final design of the framework.

Chapter 7
Cross-case comparison of supplier involvement in product development in four different companies

7.1 Introduction

In the previous three chapters we investigated supplier involvement in product development at Océ, a company operating in a high-tech industry. Using an analytical framework, we developed a more detailed understanding of the challenges of managing supplier involvement. The main output was a revised version of the initial analytical framework, that provided a holistic and integrated perspective of the relevant managerial processes and conditions. However, this framework had been developed using the empirical evidence from one company only. To further improve the revised framework, we needed to test it by applying it to different companies. The first aim of this chapter is to further corroborate our findings at Océ and to use the analytical framework on empirical cases of supplier involvement in eight development projects at four companies. In particular, we want to determine whether the framework contains all the relevant processes and conditions and whether differences in the company and project context suggest a need for a differentiated approach to managing supplier involvement. The first objective therefore addresses research questions two, three and four. The second objective of this chapter is to determine whether the IPDS framework can be used as a diagnostic instrument for detecting well-executed and problematic managerial processes that help to explain good or under-performing collaborations. It therefore also addresses research question five.

In this chapter we discuss the case research methodology, followed by a description of the main results and issues in each of the development projects. We then analyse each case study in terms of the Strategic and Operational Management Processes deployed by the companies. In the cross-case comparison, we analyse the differences between the companies in terms of processes and enabling and driving conditions. We next present the diagnostic instrument and the insights relevant to each of the four case study companies. The last section discusses the implications of the four case studies in terms of the adaptations to the analytical framework.

7.2 Case research methodology

We decided to set up a cross-sectional series of case studies in at least four or five companies in different industries. The case studies were initiated via a subproject within the PhD project, and were carried out jointly with the assistance of a graduate student[24]. The case study project was divided up into two research phases. *Phase 1* served to validate the IPDS framework by analysing supplier involvement in different contexts. *Phase 2* was aimed at transforming the framework into an instrument for self-diagnosis based on the insights and adaptations resulting from the first phase. Section 7.9 explicitly discusses the development and feedback from the participating companies. We selected eleven potential companies in different industries in order to avoid any direct competition with one another. The following four companies eventually participated in the research project: *Philips Domestic Appliances (DAP)*, *PANalytical (PAN)*, *Boon Edam (BE)* and *HJ Heinz (HJH)*. More background information is provided in section 7.3.

7.2.1 Unit of analysis and sample

As units of analysis, we decided to analyse the degree and systematic execution of managerial processes pertaining to the strategic level (not specifically related to one development project) and those pertaining to the total development project. These units of analysis allowed us to focus on the differences between companies in the contexts of companies (business units and projects) and the managerial processes. Selecting the cases in this way allowed us to address research question four. The companies themselves differed in terms of their market, technological and structural characteristics (size, R&D, supplier dependence, production complexity), although a perfect variation could not be created. However, at least one company differed on one of the driving factors. Each company was asked to submit two product development projects that differed in terms of the degree of project innovation. This criterion was based on insights from academic literature (McDermott and Handfield, 2000; Eisenhardt and Tabrizi, 1995) and from the initial case study results at Océ. Highly innovative projects had to be characterised by a high degree of novelty for the manufacturing company with regards the product functionality, architecture or manufacturing technologies used. A project was regarded as being less innovative if it involved a slight adaptation of a company's existing product. In this way, we were able to investigate whether highly innovative projects increase the need for a more active execution of Operational Management Processes. The projects should preferably already be on the market, as this would allow full measurement of the collaboration results. For time reasons, we decided to obtain an overall picture of the project's performance by asking the companies to propose two important suppliers who contributed visibly to the development of the final product. Applying the analytical framework in other contexts gave us a valuable opportunity to test its robustness. Our key informants were primarily working in the purchasing and R&D departments, although we were aware of the potential involvement of other departments (e.g. manufacturing) in certain aspects of the collaboration with suppliers during development. The choice for these two departments was

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[24] We found that some other researchers have also used assistance from graduate students in carrying out interviews (Maidique and Zirger, 1984).

driven both by the importance that the literature gives to purchasing and R&D departments as relevant internal actors and by practical feasibility reasons.

7.2.2 Case study design and data collection methods

The case studies were to be carried out based on an initial survey and a series of follow-up interviews with representatives from both the manufacturer and supplier. The survey was designed to gather data about the results, managerial processes and conditions associated with the development project and the suppliers involved in a quick and standardised way. The use of the survey required the further development of questions in line with the proposed reconceptualisation and refinement of the items of the framework, as identified in Chapter 6. Appendix 7.1 gives an overview of the results, managerial processes and conditions into specific underlying variables and elements.

We created two complementary sets of questionnaires that would address the strategic and operational perspectives on supplier involvement in product development. Both questionnaires can be found in Appendix 7.2. Since specific elements of supplier involvement are likely to be managed by different actors, we wanted to have different representatives from both purchasing and R&D departments to fill in the two types of questionnaires. The strategic questionnaire dealt with the long-term collaboration results, strategic management processes and those enablers and drivers that measured the conditions at the company or business unit level. This questionnaire was sent to the companies' purchasing and R&D managers. The second questionnaire concerned the operational management of, and conditions for, supplier involvement in the context of a specific development project. This questionnaire was sent to the people[25] who were directly involved in the product development project under study (e.g. the project leader and the project purchaser). A protocol was later developed for interviewing all people who filled in a questionnaire to discuss the project history, management processes and conditions in more detail (see Appendix 7.3). In this way, the scores could be further verified and 'adjusted' with evidence from multiple sources. Moreover, the selected suppliers were approached to provide an alternative perspective on the collaboration history and the nature of the issues and the degree to which certain enabling conditions were present or changing during the collaboration. We conducted interviews with one person who represented the commercial interface with the customer and with another person involved in the technical development of the part. A total of 45 interviews were conducted which were sent back for verification with the interviewees (detailed information on the functions of the informants are provided in Appendix 7.4). We invited all companies to participate in two plenary workshops and held in-company presentations in order to obtain feedback on the insights generated with the analytical framework and on the diagnosis instrument.

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[25] The companies could propose other key informants if they thought this would be helpful in analysing the collaboration with suppliers.

7.2.3 Case study analysis methods

In order to detect the well-executed and bottleneck processes and conditions and to try to connect them to project and collaboration results, we used the quantitative scores obtained from the questionnaires as a benchmark for comparison with the qualitative data obtained from the interviews. Collecting qualitative data in addition to a quantitative assessment strengthens the ability to interpret the observed scores. We designed the questionnaire in such a way as to collect most of the information at the project level. This means that we initially collected most information on processes and conditions pertaining to the 'average' of all suppliers involved in the project. We decided to use the subsequent interviews to focus in more detail on the enabling and driving factors that were connected to the specific collaboration with a supplier in each of the development projects studied.

In the questionnaire the collaboration results had been measured using a three-point scale, whereas a seven-point scale was used for processes, enablers and drivers. For questions pertaining to commercial aspects we regarded the answers of the purchaser as leading, whereas for technical aspects the answers from the project leader were used. Any discrepancies in the answers were marked with an asterisk '*'. Given the sheer length of the questionnaire, we decided to measure a number of enablers and drivers pertaining to the individual collaboration during the interviews. The information from the interviews was then used to characterise the results, processes and conditions and to determine which were problematic. We decided that the qualitative assessment required somewhat different scales than those of the questionnaire. The following sections explain the structure of the scales used for the questions on Results, Processes and Conditions, along with the motivation for using them.

The *Results* building block contained three groups of results: 1) Short-Term Project Results (STPR), 2) Short-Term Collaboration Results (STCR), and 3) Long-Term Collaboration Results (LTCR). Both the *STPR* and the *STCR* were measured in the light of the overall project and of the specific part development targets, respectively, using a three-point scale. The choice for actual-to-target values allowed a comparison between projects from different companies in terms of results. The *LTCR*[26] were measured, on a three-point scale, by their expected occurrence as a result of this collaboration.

After the interviews we assessed the *managerial processes* using a five-point ordinal scale, which characterised the degree of active and systematic execution of the processes. This scale was adapted from an existing instrument for assessing organisational maturity of suppliers developed by Berenschot (Praat and Krebbekx, 2000). The original scale consisted of the following labels: 1) reactive, 2) pro-active, 3) systematic, 4) professional and 5) intelligent. Since these labels did not result in clear distinctions between all categories when applied to the processes in the IPDS framework, we decided to replace some of the labels and define them as follows:

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[26] Although it would be logical to distinguish between both short-term and long-term project results in a similar analogy with the collaboration results. We did not do this because of the need to assess follow-up projects with the same suppliers. Such projects did not exist. The long-term benefits of individual suppliers, although they had not yet materialised in many cases, were the closest and most relevant type of benefits to examine.

- *Absent:* the process is not carried out;
- *Reactive:* the process is carried out in an ad-hoc way, as a result of occurring events;
- *Pro-active:* the process is carried out following an implicit structure or set of activities;
- *Systematic:* as in 'pro-active', but supported by systems, procedures and guidelines;
- *Intelligent:* as in 'systematic', but able to critically review the processes in the light of the project and to adapt (incidentally or more permanently) when necessary.

The reason for choosing a five-point scale instead of a seven-point scale is that it allows a more meaningful interpretation of the scale points and therefore strengthens the interpretation of results in a cross-sectional case study setting. Compared to a three-point scale, the proposed five-point scale would enable the researchers to characterise a managerial process more accurately. After the questionnaires had been returned, we learnt from the feedback that smaller scales would make it easier to answer the questions. This was important input for the later design of the self-diagnosis instrument.

The *conditions* (enablers and drivers) were measured in terms of their degree of presence, using a three-point scale. Having finalised our research design, designed our measurement instruments and carried out the interviews, we went through cycles of analysing the interview material, case by case, to detect bottlenecks in processes and conditions that could be associated with the observed collaboration and overall project results. We then performed a cross-company comparison of the scores on conditions, processes and results, including a comparison with the findings from the Océ case study.

7.3 Case study background and results

In this section we describe the background of the selected companies, development projects and parts in greater detail. We then highlight the main results and issues in these cases.

7.3.1 Company and case study background

Four companies operating in four different industries participated in this stage of the research project. Table 7.1 summarises the cases and the number of interviews held per project.

Figure 7.1 DAP Vacuum cleaner

The first case study company **Philips Domestic Appliances (DAP)** belongs to one of the largest Philips divisions and develops and manufactures personal care products and home appliances such as shavers, coffee machines and vacuum cleaners. The production is based on mass-assembly. DAP submitted the *Vacuum cleaner* and *Creme Coffee Machine development projects*. The first project concerns the development of a fragrance module for a high-end specialist vacuum cleaner series. The unique element in this project was the location of the fragrance module on the exterior of the vacuum cleaner, thus increasing the importance of 'design appearance'. The fragrance was developed with the help of a consultancy agency (A) specialised in the fragrance market. The project was regarded as being moderately innovative, considering it involved an extremely new functionality introduced to an existing product. The second project concerned the redesign of a boiler for a follow-up version of a highly successful and innovative creme coffee machine that had introduced a new way of coffee making. The project was regarded as having a low innovative level. In this project DAP collaborated with a European supplier (B) of heating elements for kettles and coffee machines on the redesign of the boiler.

Figure 7.2 Creme coffee machine

Table 7.1 Case study companies, development projects and parts

	Philips Domestic Appliances		PANanalytical		Boon Edam		H.J. Heinz	
Projects	Vacuum Cleaner	Creme Coffee Machine	Energy Dispersive Spectrometer	Sample Changer	High Speed Safety Gate	Revolving Door family 2 versions	Ready-to-drink slightly carbonated soda	New flavour for fruit-flavoured sprinkles
Degree of innovation	Med-High	Low	High	Low	High	Low	High	Low
Parts developed	External fragrance module	Boiler system	Detector system high voltage generator metal casing and mechatronics assy software package	Three dimensional straight-line guide way.	Sensor-package + control box Steel gate construction	Steel centre column Stainless steel centre column	Bottle filling production supplier	Process supplier for fruit sprinkles production
# interviews	11		15		11		8	
Suppliers	Supplier A	Supplier B	Supplier C, D, E, F	Supplier G	Supplier H,I	Supplier J,K	Supplier L	Supplier M

PANalytical, **(PAN)** is an analytical instrumentation and software supplier for industrial process control and R&D applications around the world.

The company offers X-ray analytical equipment for industrial and scientific applications as well as for the semiconductor market. PAN is a large company and is characterised by small-series production.

Figure 7.3 Sample changer

In the highly innovative '*Spectrometer project*' PAN developed a novel system for analysing samples using a newly developed detection technology (energy dispersive). This project was carried out with the help of four suppliers, supplying: 1) a detector system (supplier C), 2) a high voltage generator (supplier D), 3) a metal casing and mechatronics assembly (supplier E), and 4) an embedded software board (supplier F). In the low innovation *sample changer project*, PAN developed a customer-specific system for analysing a higher capacity of samples than in the standard product. Moreover, it had to be able to work with sample trays. One of the key suppliers (G) in this project was involved in the development of a module to provide the guiding technology and housing of the sample changer.

Boon Edam (BE), is the world market leader in the area of revolving doors and security products for the high-end market, and has subsidiaries around the world. Typical end-customers include shopping centres, airports and other large construction projects. BE is a medium sized company and its production is largely project-based. The first project concerned a *high-speed safety-gate* belonging to BE's security products group. The entry gate, which is about 1.2 m in height, is usually found in buildings in a supervised area where large numbers of people need to enter and leave. The gate was actually derived from a product already manufactured by one of BE's subsidiaries. However, the major redesign resulted in a highly innovative product for BE and was carried out mainly with the help of two suppliers (G and H), supplying: 1) a sensor-package with a control box, and 2) the steel construction. In the second low innovation development project, two slightly different types of a high capacity glass revolving door were developed with differing diameters and door columns made of two different types of steel.

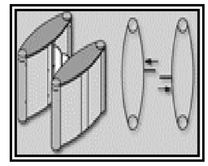


Figure 7.4 High Speed Safety gate

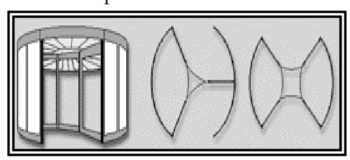


Figure 7.5 High capacity revolving door

HJ Heinz (HJH) is a large multi-national food and beverages company, which develops and produces quick-serve meals and meal solutions. The production type is therefore process based. Although we refer to HJ Heinz, the cases deal primarily with the practices of one of its recently acquired Dutch operating companies formerly known as *Koninklijke de Ruiter (KdR),* a producer of sandwich spreads. The first project concerned a *ready-to-drink slightly carbonated soda beverage in PET bottles of 33 cl*. The drink was developed and filled in collaboration with a Spanish subsidiary of a Dutch filling company (supplier I). The project was chosen as a highly innovative project because of the challenging and new combination of manufacturing processes, packaging and product concepts. The second project concerned a new flavour for fruit-flavoured sprinkles and was selected as being less innovative because it was a line extension. HJH regarded this project as an outsourcing project and involved a co-packer (supplier J) during product development. A co-packer is a production specialist.

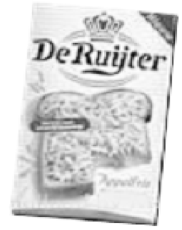


Figure 7.6 Fruit-flavoured sprinkles

7.3.2 Results and major issues

Short-term collaboration and operational project results

When analysing the overall project performance in terms of its *short-term operational results* (Table 7.2), we notice that, according to the respondents, 'product quality' scores met their targets in all of the projects. In contrast, the 'product cost price' appeared to be hard to control for three of the projects, with the failure to achieve initial targets resulting in initial sales problems for one project. With respect to the 'development costs', respondents judged the results to be on target. However, interviews revealed that not all relevant development costs were being monitored (e.g. extra co-ordination costs related to resolving intermediate quality problems) and we therefore need to be careful when interpreting this on-target judgement. The 'time-to-market' targets were largely met in seven out of eight projects. HJH and PAN even succeeded in developing the beverage and sample changer products faster than originally planned. However, the spectrometer project at PAN was introduced with a delay.

Table 7.2 Results of supplier involvement and development projects

		Short-term Collaboration Results*				Short-Term Operational Project Results*			
Com-pany	**Project**	**Part Technical Performance**	**Part Cost**	**Part Develop-ment cost**	**Part Develop-ment time**	**Product Quality**	**Prod uct Cost**	**Develop-ment Cost**	**Time-to-market**
DAP	Vacuum Cleaner	3	2	2**	2	3	2	3	2
	Coffee machine	2	2	2	2	2	2	2	2
PAN	Spectro-meter	1.75	1.5	1.5	1.5	2	1	1	1
	Sample-changer	2	2	2	2	2	2	2	3
BE	Speed gate	2.5	2	2**	2	3	1	2**	2
	Revolving door	2	2	2**	2	2	1	2**	2
HJH	Carbonated Soda drink	2	2	2	3	2	2	2	3
	Fruit Sprinkles	2	2	2	2	2	2	2	2
	Overall average	**2.0**	**1.9**	**1.9**	**2.1**	**2.3**	**1.9**	**2**	**2.1**

* The short-term collaboration results have been measured using the self-reported questionnaire scores for the collaborations studied. We used the scores from the buyer for the Part cost and used the project leader's answer for the remaining results. Where possible we later on checked in interviews with buyer and engineers the results indicated. Descrepancies were discussed and accompanied by comments such as provided under *** below.

** The short-term operational project results are the project leader's self-reported scores. However the answers have been transformed to a similar 3-points scale for analytical purposes (1 = worse than target 2= on target and 3 = better than target).

*** The reported results on development costs are most likely not the complete costs. The governance costs in terms of contracting and co-ordinating development activities concerning different departments are certainly higher than expected but are not quantified or quantifiable.

We can see more variation in performance if we zoom in on the *short-term results of the collaborations* studied (see Table 7.2). In seven out of eight projects the collaborations with suppliers achieved sufficient 'technical performance' at the end of the project. An exception was the collaboration with the generator supplier in the spectrometer project. At DAP the technical performance/quality of the fragrance module exceeded initial expectations and targets. Similarly, the collaborations at BE in the speed gate project also contributed strongly to the final product functionality and aesthetic design performance. However, during production ramp-up unexpected reliability problems with the sensor package were encountered but solved quickly. 'Cost price' deviations for individual parts certainly affected the final product cost in a negative way in the spectrometer project (PAN). In the other projects the higher cost price of the final product cannot be explained by the on-target cost performance of the parts investigated. In terms of 'development costs' used in each collaboration, Table 7.2 shows a positive picture. Again, we should be careful in concluding that the targets have been met, as we observed unexpected (technical) issues during the collaboration with suppliers in all companies (DAP, vacuum cleaner project; PAN, spectrometer project; BE, speed gate project; HJH). The occurrence of unexpected design changes may have consumed more attention and resources (engineering costs, prototypes) than was anticipated; it is difficult to determine how much because not all companies have an accurate idea about the amount of resources that went into a specific collaboration. Finally, the scores on the 'part development time' targets point out that in one project at PAN more time was needed to finish the development with the suppliers than planned. In contrast, at HJH the collaboration in the beverage project was a significant contributor to a fast time-to-market. Other collaborations neither slowed down nor sped up the overall project's time-to-market.

Long-term collaboration results

In addition to the performance of the projects and collaborations, we examined the benefits that companies expected to achieve from the various collaborations (see Table 7.3).

Table 7.3 Long-term collaboration results

Expected occurrence of Long-Term Collaboration Results[27] in the future			
	(1) Alignment of Technology Roadmaps	**(2) Improved Access to Supplier's knowledge**	**(3) More effective + efficient future collaboration**
DAP	2.0	2.5	3.0
PAN	1.63	2.0	2.0
BE	1.0	1.75	1.75
HJH	2.0	2.5	2.5
Average score	**1.4**	**2.0**	**2.1**

Most companies expected learning experiences in various collaborations to result in improved designs and more efficient co-ordination and communication between both parties in future collaborations. This benefit was closely followed by collaborations in which the buying company expected to have better access to the supplier's knowledge in the following collaboration. The alignment of technology roadmaps was less visible, but seemed to occur in companies such as DAP and HJH.

Issues

These mixed results were preceded by a number of issues that characterised the collaboration and its management. We now briefly summarise the main issues encountered before and during the collaborations. At DAP, the main issues in the collaboration were the unclear and changing roles and responsibilities between DAP and the supplier during the development of the fragrance module. We also observed an unexpected design iteration. In addition, DAP

[27] Respondents were R&D and purchasing managers. For each of the benefits, the respondents were asked to assess the extent to which they agreed a benefit was expected to be achieved in the future. This table contains the average of corrected scores for examined suppliers in both projects. The correction was made by transforming an initial 7-point scale to a 3-point scale (where 1= not expected to occur, 2= expected to occur, though not strongly, 3= strongly expected to occur). Interviews were used to verify the transformations.

initially set unrealistic cost price targets. In the creme coffee machine project, unstable specifications revealed that the functional design of the boiler was not yet ready. Moreover, extensive discussions with the selected supplier took place to meet the production numbers and in an effort to find a second source. At PAN the overall software development (spectrometer project) took longer than expected. For the instrument control software development, the embedded software design was characterised by shifts in the in-outsourcing of development tasks and changing functional requirements. Furthermore, two collaborations were particularly characterised by intermediate technical problems. Unexpected cost price increases during development, obtaining timely responses to requests from PAN during prototype cycles, and the timely attendance of scheduled meetings were among the main issues in the high voltage generator collaboration. At BE some technical issues occurred when developing the sensor application in the security gate project. Moreover, the project progress was endangered when the BE electronics engineer fell ill.

These initial observations suggest that the companies were largely in control of their technical performance, but that the resources in terms of man-hours and time were difficult targets to keep. This suggests that the process of collaboration is not a simple roll-out process. We therefore need to examine the way in which these companies approach supplier involvement in the strategic and operational project management arenas. For each company, we will first describe the scores on the Strategic Management Processes, followed by the scores and characteristics by which the operational collaboration was managed. The reported scores are the adjusted questionnaire scores of the key informants for the Strategic and Operational Management Processes mentioned in section 7.2.2. The scales are based on the five-point scale as reported in section 7.2.3.

7.4 Managing supplier involvement at Philips Domestic Appliances (DAP)

7.4.1 Analysing the strategic management of supplier involvement

In Figure 7.7 we see that DAP is working towards a systematic approach to its innovation and supplier involvement process. It is engaged in a pro-active and systematic policy and supplier base development. Through its technology and product roadmaps, DAP aims to determine the need for future technologies and parts and to discuss such plans with key suppliers. Strategic Purchasing is increasingly monitoring

Figure 7.7 DAP Strategic Management Processes

1. Determining technology in-outsourcing policy	4
2. Formulating and communicating guidelines for SI	3
3. Monitoring supplier(s)(markets) for relevant developments	3
4. Pre-selecting suppliers for involvement in future NPD	4
5. Exploiting suppliers' skills and capabilities	4
6. Motivating suppliers for developing products/investing...	3
7. Evaluating guidelines and supplier base	4

supplier markets for new technologies and concepts, and this alignment is created through commodity strategies. Purchasing has recently become represented in internal technology roadmaps sessions. In addition, DAP tries to pre-select suppliers for involvement in product development. Besides using a supplier status (partners are most intensively involved in development), DAP involves suppliers before a development project starts. Their most striking practice is the independent function creation process in which the feasibility of different technologies and concepts are assessed before they are accepted in a product development project. Strategic Purchasing is connected to the advanced development group and guides the pre-project involvement of suppliers in function development. Finally, DAP formulates, communicates and evaluates guidelines and practices that facilitate decision-making processes and the collaboration with suppliers in development.

7.4.2 Analysing the managerial processes in the vacuum cleaner fragrance development project

Analysing the way DAP dealt with the *operational management* of the collaboration (see Figure 7.8), we note that the fragrance module was clearly going to be developed with the help of external suppliers (OMP1). Due to time pressures, however, DAP was limited in thoroughly comparing alternative suppliers and therefore chose the supplier that was known via a previously established contact with R&D. Selecting suppliers as a process therefore scores badly. One of the most pressing problems in the collaboration followed from the gradually increasing number of tasks that DAP asked the supplier to perform. The supplier was a consultancy company specialised in fragrances and was initially asked for advice on scents (consultancy role), but gradually assumed a co-ordinating role for the supply base during the development, and the responsibility for logistics related to the delivery of the fragrance module. Moreover, DAP initially determined a target cost price without actually knowing whether it was realistic. On the other hand, the supplier did not provide sufficient critical feedback and accepted this target, although this had to do with the supplier's perception of its consultancy role. This suggests that DAP did not clarify beforehand what exact role and responsibility the supplier was truly willing and capable to play. Moreover, it did not put much effort into verifying whether its requests were realistic (OMP4,5). From the supplier point of view, communication with DAP was not always easy to co-ordinate, as several project members approached the

Figure 7.8 DAP vacuum cleaner project Operational Management Processes

1.	Determining desired develop& buy solutions	**4**
2.	Suggesting alternative technologies/suppliers	**2**
3.	Selecting suppliers for involvement in a project	**2**
4.	Determining extent and timing of involvement	**2**
5.	Determ. dev. work-package and operational targets	**3**
6.	Designing communication interface	**3**
7.	Co-ordinating suppliers' development activities	**2**
8.	Evaluating part designs	**4**
9.	Evaluating supplier development performance	**2**

supplier with different requests at the same time (OMP7). Therefore, although the communication interface may have been properly designed from DAP's point of view, the supplier's actual experience may contradict this. We did observe that a pilot evaluation effort partially helped to improve the co-ordination of development activities with the supplier by adjusting the communication interface (OMP9).

7.4.3 Analysing the managerial processes in the creme coffee machine development project

In setting up the development of the second generation creme coffee machine, we note a rather smooth start-up of development activities. The project team identified the boiler unit as a unit whose engineering and production would be outsourced as in the first project. DAP wanted to remain in control of all specification activities for the boiler functionality, while the remaining development and production activities were candidates for outsourcing. The supplier selection quickly resulted in choosing a known preferred supplier. However, the need for an additional supplier later on in the project, to meet unexpected high production volumes, required significant extra co-ordination efforts. The extent of involvement was not systematically determined due to the presence of a supplier with known capabilities for the development of the boiler. DAP initiated preliminary contacts with the boiler supplier before the official project was given the go ahead and were therefore able to start on time. This explains the low scores on Operational Management Processes 2-4. The co-development collaboration was characterised by a number of technical problems. These were triggered by unstable functional requirements for which DAP was responsible. These problems were detected during design evaluations and resolved with the input of the technically capable supplier (ref: project leader). The co-ordination of the redesign did not result in significantly higher development costs. However, the evaluation of the design regarding the availability of components and cost price were items that demanded a relatively large amount of attention from DAP. Due to the unexpected high demand for the first coffee machine, other extensive discussions took place about increasing production numbers and the availability of components.

Figure 7.9 DAP coffee machine project Operational Management Processes

1.	Determining desired develop& buy solutions	**4**
2.	Suggesting alternative technologies/suppliers	**2**
3.	Selecting suppliers for involvement in a project	**2**
4.	Determining extent and timing of involvement	**2**
5.	Determ. dev. work-package and operational targets	**4**
6.	Designing communication interface	**3**
7.	Co-ordinating suppliers' development activities	**3**
8.	Evaluating part designs	**4**
9.	Evaluating supplier development performance	**1**

7.5 Managing supplier involvement at PANalytical (PAN)

7.5.1 Analysing the strategic management of supplier involvement

If we analyse the general scores on the Strategic Management Processes, PAN appears to be pro-actively engaged in building a supply base and creating support for development projects. The Development, Operations and Purchasing directors are involved in a formal process of determining the core and non-core technologies and make-buy decision-making. They are linked to a structured product development process supported by formal procedures and guidelines such as action plans and risk analyses. The guidelines for collaborating with suppliers in product development are present (supplier selection, audits, contracts, purchasing portfolio), but are barely communicated to suppliers and are not reviewed on a regular basis. As one of the purchasing representatives stated, 'people tend to act mostly based on their own experience'. The process SMP7 therefore receives a low score. What is positive is the pro-active effort of both R&D and Purchasing in keeping themselves actively up-to-date about technological developments and available suppliers. Given the number of specialist technologies, PAN can only choose from a very limited number of alternative suppliers; this sometimes results in obvious supplier choices. PAN motivates suppliers through shared investment plans. PAN does have a preferred supplier list for different commodities and assesses the innovative capabilities of suppliers. PAN has recently decided to explicitly consider outsourcing/co-development as one of the six competences in which it needs to excel. Specific multi-disciplinary commodity teams are active to support the development and procurement of specific parts of the final product. Each year they present the future supply base strategy to the Operations, Purchasing and R&D management.

Figure 7.10 PAN Strategic Management Processes

1.	Determining technology in-outsourcing policy	**3**
2.	Formulating and communicating guidelines for SI	**3**
3.	Monitoring supplier(s) (markets) for relevant developments	**3**
4.	Pre-selecting suppliers for involvement in future NPD	**3**
5.	Exploiting suppliers' skills and capabilities	**3**
6.	Motivating suppliers for developing products/investing...	**3**
7.	Evaluating guidelines and supplier base	**2**

7.5.2 Analysing the managerial processes in the spectrometer development project

The spectrometer project was a new and complex project and was carried out with the help of four suppliers, supplying: 1) a detector system (supplier A), 2) a high voltage generator (supplier B), 3) a metal casing and mechatronics assembly (supplier C), and 4) an embedded software board (supplier D). At operational level, we notice that PAN managed the involvement of its suppliers in a pro-active way in the spectrometer project. PAN made an analysis of the parts in the module for which the desired level of supplier involvement was determined. However, the detector was defined in such a way that the opportunity to consider alternative suppliers was very limited. In this case technical reasons were decisive when choosing the one available supplier. The supplier selection proposal was prepared by the cross-functional project team and was reviewed and approved by a cross-functional management review board. One exception was the new generator supplier, who was primarily chosen by the project team on the basis of an attractive quotation, thereby neglecting the long-term and strategic considerations for choosing this supplier (ref: development manager). Supplier selection of well-known suppliers was carried out effectively. However, some risks in new collaboration areas or with new suppliers were not detected or dealt with in advance. Although PAN did pro-actively determine the extent of supplier involvement, we observed that during the project the final develop-or-buy solution for the embedded software board migrated from outsourcing to internal development (because the supplier quotation was considered to be too high) and back to outsourcing (because internal knowledge appeared to be insufficient). These events increased the overall co-ordination and development costs. PAN made agreements regarding targets but did not determine consistently and in all cases how and between whom the communication would flow (ref: supplier B). In the other collaborations they did arrange communication between technical and commercial representatives on both sides. The collaboration worked especially well in the development of the metal housing and mechatronics assembly. However, in two of the collaborations the co-ordination of development activities with suppliers appeared to be somewhat problematic (OMP2). These suppliers did not always respond on time according to PAN, and in one collaboration the cost price was unexpectedly increased by the supplier. The process of evaluating software designs was problematic (OMP8). According to the development manager the software requirements and specifications did not always match the actual functional behaviour. In addition, the software technology and hardware were subject to such fast changes that it became a challenging task to keeping up the internal software programming knowledge and to manage the documentation package. In this project the software requirements tended to change during development, resulting in extra development cycles and costs that had not been foreseen in the project agreement. Finally, the process of evaluating the suppliers' development performance scores very low. Although this is an explicit step in PAN's product development process, it was hardly ever carried out jointly with the supplier, thus suggesting a weak link with (exploiting) learning experiences.

Figure 7.11 PAN spectrometer project Operational Management Processes

1.	Determining desired develop& buy solutions	**4**
2.	Suggesting alternative technologies/suppliers	**3**
3.	Selecting suppliers for involvement in a project	**3**
4.	Determining extent and timing of involvement	**3**
5.	Determ. dev. work-package and operational targets	**3**
6.	Designing communication interface	**3**
7.	Co-ordinating suppliers' development activities	**2**
8.	Evaluating part designs	**4**
9.	Evaluating. supplier development performance	**1**

7.5.3 Analysing the managerial processes in the sample changer project

In this project an existing product was adapted to add a functional requirement from one customer. The sample changer was largely developed with two suppliers. The choice for the first tier supplier was an obvious one, as it was the supplier of the current version of the sample changer. The supplier was involved in a co-development collaboration. It was agreed with the guideway supplier that they would assemble the cabinet and the guideway. The initial collaboration with the second tier supplier for the cabinet of the sample changer resulted in prototypes of insufficient quality. PAN therefore wanted to change its selected second tier supplier. Following a suggestion from the guideway supplier, PAN involved a new cabinet supplier but clearly agreed that the guideway supplier would be the main contractor and would co-ordinate most of the development activities with the cabinet supplier. The evaluation of designs were properly carried out without major problems, which contributed to meeting the time-to-market target. The only problems in maintaining the technical documentation package occurred when the customer-specific sample changer product was further developed into a regular product for other customers. PAN decided rather late in this process to leave some of the testing activities to the supplier. We note that most issues were resolved during the project, but PAN did not evaluate the development performance jointly with the supplier. Such an evaluation could be helpful in achieving closure (even when there were no problems). In addition, best practices could also be derived from this collaboration, which could help to prevent issues from arising again in future projects.

Figure 7.12 PAN sample changer project
Operational Management Processes

1.	Determining desired develop& buy solutions	**4**
2.	Suggesting alternative technologies/suppliers	**2**
3.	Selecting suppliers for involvement in a project	**1**
4.	Determining extent and timing of involvement	**3**
5.	Determ. dev. work-package and operational targets	**3**
6.	Designing communication interface	**3**
7.	Co-ordinating suppliers' development activities	**2**
8.	Evaluating part designs	**4**
9.	Evaluating supplier development performance	**2**

7.6 Managing supplier involvement at Boon Edam

7.6.1 Analysing the strategic management of supplier involvement

BE is a medium-sized company that has not traditionally involved suppliers to a large extent. The low scores on the Strategic Management Processes are indications of this. We note specifically that no guidelines are used to involve suppliers in product development. In addition, there is limited clarity regarding the in-outsourcing policy for technology and product development. We notice BE's preference of keeping internal control over certain development/ engineering and assembly processes. This often results in outsourcing of production assignments, while development and assembly of higher-level modules is done in-house. We can therefore see that they do not yet use supplier technologies/products as a starting point for designing new products. They do pre-select suppliers for technologies when a need is foreseen for a future project, but this does not occur in a systematic way. The purchasing department does have a preferred supplier list for production suppliers, but there is no shared list between the purchasing and R&D departments for product development contributions. Such a list exists only in the minds of the R&D members. BE does not yet implement a cycle of systematically linking future product and technology needs with building up a different supply base to support strategic choices.

Figure 7.13 BE Strategic Management Processes

1.	Determining technology in-outsourcing policy	**2**
2.	Formulating and communicating guidelines for SI	**1**
3.	Monitoring supplier(s) (markets) for relevant developments	**3**
4.	Pre-selecting suppliers for involvement in future NPD	**3**
5.	Exploiting suppliers' skills and capabilities	**2**
6.	Motivating suppliers for developing products/investing...	**3**
7.	Evaluating guidelines and supplier base	**1**

7.6.2 Analysing the managerial processes in the high speed safety gate project

In the high-speed safety-gate project, we note that BE spent little time on the majority of the Operational Management Processes. None of the collaborations were set up in a pro-active and systematic fashion (reflected in the low scores for OMP 1-5). Both suppliers were already known to the company and used a pragmatic approach driven by a particular problem. R&D suggested the suppliers and started off by asking for sensor prototypes and, in the second case, by sending the drawings of the frame construction. The sensor supplier therefore made the largest contribution. Since BE did not have sufficient internal knowledge on sensors, the sensor supplier brought in functional knowledge by actively suggesting alternative solutions and implementing concept changes. The contribution of the sheet-metal supplier was limited to providing feedback on the drawings regarding manufacturability; this corresponded to the traditional low extent of involvement. However, its production technology did contribute to an aesthetically satisfactory housing. No formal project plan or communication interface were designed (OMP 5,6), except agreements on deadlines, price targets and technical information. The co-ordination of

Figure 7.14 BE speed gate project Operational Management Processes

1.	Determining desired develop& buy solutions	**2**
2.	Suggesting alternative technologies/suppliers	**3**
3.	Selecting suppliers for involvement in a project	**2**
4.	Determining extent and timing of involvement	**2**
5.	Determ. dev. work-package and operational targets	**3**
6.	Designing comm. interface	**1**
7.	Co-ordinating suppliers' development activities	**2**
8.	Evaluating part designs	**3**
9.	Evaluating supplier development performance	**1**

development activities was more proactive with the sensor supplier. The evaluation of designs therefore occurred in an iterative fashion between the engineers from both sides. A problem occurred when the BE electronics engineer fell ill and his work had to be taken over. A new supplier was sought for specific engineering activities and, in the end, the sensor package was finished. The evaluation of prototypes did not result in foolproof testing procedures, however. Some reliability problems were still present during the first deliveries.

7.6.3 Analysing the managerial processes in the high capacity revolving door project

This project concerned a high capacity glass revolving door whose diameter was between 3.6m and 6m. The doors, called the 'Star' and 'Full-view', were derived from a basic revolving door concept. These were related projects involving two different suppliers for the door columns. The operational collaborations in this projects were typical routine collaborations with low levels of supplier involvement. The develop-or-buy solutions were therefore an obvious choice for BE. Suppliers were selected quickly from the supplier base of preferred production suppliers. Whereas the R&D department regarded engineering capacity, speed and technical capabilities as important selection criteria, the purchasing department was mainly driven by cost price considerations. Since it concerned the parts for the door column, few alternative technologies were considered. The engineer defined the parts and chose the materials. Purchasing did not have any influence on the definition of the parts and the desired supplier input in development. At the start of the collaboration BE agreed on target cost prices and time schedules, but no development contracts were used. Furthermore, BE did not spend time on setting up a communication structure in advance of the projects; the communication evolved throughout the project. When developing steel or sheet metal parts the BE engineer typically makes the drawings and sends them via Purchasing to the supplier. In these cases both suppliers evaluated the drawings provided by BE and came up with feedback and suggestions to simplify the design and to improve manufacturability. In one case the engineer from BE actively sought contact with the steel supplier. This resulted in effectively detecting and solving some manufacturability problems before production started. In the case of the supplier of the stainless steel column, no direct contact between the engineer and supplier took place (resulting in a low score on co-ordinating development activities). Finally, we observe

Figure 7.15 Operational Management Processes
BE High capacity revolving door project

1.	Determining desired develop& buy solutions	**2**
2.	Suggesting alternative technologies/suppliers	**1**
3.	Selecting suppliers for involvement in a project	**2**
4.	Determining extent and timing of involvement	**2**
5.	Determ. dev. work-package and operational targets	**3**
6.	Designing comm. interface	**1**
7.	Co-ordinating suppliers' development activities	**2**
8.	Evaluating part designs	**3**
9.	Evaluating supplier development performance	**2**

that the evaluation of suppliers' development performance did take place in the minds of the people involved, but no formal (joint) evaluation sessions actually took place.

7.7 Managing supplier involvement in product development at H.J. Heinz

7.7.1 Analysing the strategic management of supplier involvement

We particularly studied the processes and projects in one of the divisions acquired by HJH, which, as a former Dutch company, developed various types of flavoured sprinkles and had diversified into the development of beverages. We focused on the collaboration with two so-called co-packers. A co-packer's main task is to produce final food or beverage products. As such, it needs to be involved early in the development process to fine-tune packaging and ingredient specifications with appropriate production line specifications so as to achieve the desired quality and production quantities.

Figure 7.16 H.J. Heinz Strategic Management Processes

1.	Determining technology in-outsourcing policy	**5**
2.	Formulating and communicating guidelines for SI	**5**
3.	Monitoring supplier(s) (markets) for relevant developments	**4**
4.	Pre-selecting suppliers for involvement in future NPD	**4**
5.	Exploiting suppliers' skills and capabilities	**3**
6.	Motivating suppliers for developing products/investing...	**4**
7.	Evaluating guidelines and supply base	**5**

At HJH, we notice that the Strategic Management Processes are systematically and cross-functionally executed. Policies for outsourcing are developed for different product development and production disciplines/tasks (SMP1). Supplier involvement is typically defined for areas of taste development, using flavour houses and ingredient suppliers, for product packaging, using packing suppliers, and for production line development, in which the final production suppliers or co-packers take the primary lead. For each of these areas, HJH consciously looks for different types of preferred partners, which does not necessarily mean a single source strategy. Yearly strategy review meetings are held with the supplier as a long-term relationship instrument; this enables them to learn about the technological possibilities, but also to motivate the supplier to invest in certain production capabilities in line with future product/market combinations (SMP3 and 6). Although they have different process blue prints for managing supplier involvement (SMP2) and for evaluating them (SMP7), their major challenge is now to integrate the routines developed in this formerly independent company into the large HJH organisation.

7.7.2 Analysing the managerial processes in the carbonated soda drink development project

Figure 7.17 HJH carbonated soda drink project Operational Management Processes

1.	Determining desired develop& buy solutions	**4**
2.	Suggesting alternative technologies/suppliers	**4**
3.	Selecting suppliers for involvement in a project	**3**
4.	Determining extent and timing of involvement	**4**
5.	Determ. dev. work-package and operational targets	**4**
6.	Designing communication. interface	**3**
7.	Co-ordinating suppliers' development activities	**4**
8.	Evaluating part designs	**3**
9.	Evaluating supplier development performance	**5**

In the first project the drink was developed and filled in collaboration with a Spanish subsidiary of a Dutch filling company. The challenges for HJH and the supplier were the new method of preparation in combination with the packaging material and the manufacturing technology. Moreover, they considered meeting the time-to-market to be of utmost importance, since frequent product introductions make the beverage market highly volatile. The project was realised, from scratch, within less than six months. Both the supplier and the project team members from HJH contributed to this positive result on all of the performance dimensions. HJH appeared to follow a systematic approach in involving the suppliers in the beverage project. The choice of the supplier selected in this project followed a well-structured comparison of alternatives (OMP2). A visit by different members of HJH's project team to meet the supplier and discuss the project's targets and workloads further increased the commitment internally (OMP4). It also created a positive impression at the supplier regarding HJH's professionalism. However, a specific intermediary had to be assigned between HJH and the supplier's subsidiary, as there were some communication difficulties caused by language differences and distance. This adapted interface was crucial in co-ordinating the joint development activities and maintaining the speed in the project. After the project both parties conducted a joint evaluation of the collaboration.

7.7.3 Analysing the managerial processes in the fruit-flavoured sprinkles development project

The second project concerns a line extension/new flavour for fruit-flavoured sprinkles, in which we studied the collaboration between HJH and a co-packer during the product development. The co-packer already owned the production line for the original version of the fruit-flavoured sprinkles. In this project, time pressure was very high and resulted in difficulties in meeting minor packaging requirements, even though this was a usual item on the checklist. We note that most of the processes were carried out in a largely systematic way. We also note that the process of selecting suppliers was not systematically carried out, because the choice was rather obvious. This did not mean that the selection itself was skipped, but that the team approved the choice of a well-known supplier with Purchasing taking the lead. Given the fact that the co-packer got involved to a lesser extent in taste development than it potentially could have, we also score the process of determining the extent of supplier involvement somewhat lower. HJH argued that it decided to somewhat limit the involvement due to the nature and time pressure of the project. However, the co-packer did start raising questions and providing suggestions in the domain of flavouring even though this was a development area that was kept primarily in-house and with the flavour supplier. HJH therefore had to actively co-ordinate the development activities between the co-packer and the flavour supplier. The question is how far this should go without getting blurred lines of responsibility and without curbing a spontaneous and pro-active attitude from the co-packer in this project. HJH stressed that this project reminded them to define the collaboration domain as early as possible and to explicitly discuss mutual expectations (OMP1 OMP4,OMP5).

Figure 7.18 HJH fruit-flavoured sprinkles project Operational Management Processes

1.	Determining desired develop& buy solutions	**4**
2.	Suggesting alternative technologies/suppliers	**3**
3.	Selecting suppliers for involvement in a project	**3**
4.	Determining extent and timing of involvement	**3**
5.	Determ. dev. work-package and operational targets	**4**
6.	Designing comm. interface	**5**
7.	Co-ordinating suppliers' development activities	**4**
8.	Evaluating part designs	**4**
9.	Evaluating supplier development performance	**5**

7.8 Cross-case analysis

In the previous case studies we encountered at least three dominant issues in the various collaborations. Firstly, we observed that companies sometimes set non-realistic technical and price targets. Secondly, the technical requirements and expected contribution from a supplier sometimes changed unexpectedly during the collaboration. Finally, we noticed that project teams are putting increased time and effort into co-ordinating activities with suppliers. We now turn to analysing the most striking differences between the supporting and bottleneck processes and conditions that contributed to the observed short-term and expected long-term results of the various collaborations. We will also reflect on the role of company and industry differences and examine the differences for highly innovative and less innovative projects.

7.8.1 Cross-case comparison of the Operational Management of supplier involvement

We expected companies that pro-actively and systematically manage the operational collaborations with suppliers in a development project to demonstrate high collaboration results. The results and scores of the companies investigated partially meet this expectation. In

Table 7.4 we first analysed the average scores for the Operational Management Process. In terms of the operational management of the collaboration, HJH was able to involve its suppliers based on a systematic execution of the listed processes (highest score: 4.0). DAP, on the other hand, scored lower 2.7 (highest score). DAP appears, on average, to have been less pro-active than PAN (highest score: 3.0). However, PAN did not carry out all decision-making processes equally consistently in all collaborations. BE scored worst (highest score: 2.1) on the operational management processes in the Project Management arena.

We now link these scores with the results of the collaboration and of the overall project. While the high process scores at HJH are associated with their quality, time and cost performance being largely on target, DAP achieved most of the targets in the vacuum cleaner project with lower process scores. However, we noted earlier that the collaboration in the vacuum cleaner project (fragrance module) consumed more 'invisible development resources' (attention time). PAN's relatively pro-active operational management of supplier involvement did not consistently prevent problems and below target performance in all projects, with the exception of the spectrometer project. Surprisingly, BE did achieve most of its targets with its relatively reactive and ad hoc management of supplier involvement. We once again note that the reliability in the safety gate project was a problematic quality aspect requiring late and extra attention, and that the (extra) development costs are still not fully known.

Table 7.4 Overall scores on managerial processes

Company	Project	Strategic Management Processes			Operational Management Processes	
		Degree of support to OMP	Average	Range/ tendency	Average	Range/ tendency
DAP	Vacuum cleaner	Medium	3.6	3-4	**2.7**	1-**4**
	Coffee machine	Medium			**2.7**	1-4
PAN	Spectrometer	Low-to-medium	2.9	2-**3**	**3.0**	1-**4**
	Sample Changer	High			**2.7**	1-4
BE	Speed gate	Low	2.1	1-3	**2.1**	**1**-4
	Revolving door	Low			**2.0**	1-**3**
HJH	Carbonated soda drink	High	4.3	3-**5**	**3.8**	1-**5**
	Fruit sprinkles	High			**4.0**	1-**5**

If we zoom in further on specific processes, we find that at the operational level HJH was consciously trying to be explicit about the domain of collaboration and was assessing the technical, commercial and financial risks internally and with potential suppliers. Selecting suppliers (OMP3) often received a low score, because in some of the collaborations suppliers were already known and available. However, cross-functional assessment and selection remain an important process by which to identify potential (technical and business) risks, even with a current or a monopolist supplier (DAP, PAN, BE). After the supplier was selected, HJH visibly spent time on discussing the content of the work package and targets with the supplier.

Projects at DAP, PAN and BE exhibit somewhat lower scores for determining the extent of supplier involvement and defining the work package and targets with the supplier.

This points to an insufficient identification of risks and agreements about each other's roles with suppliers. Furthermore, we found that multiple project teams were agreeing on spokespersons on both sides (OMP 6). However, we observed that the swiftness of designing an appropriate communication interface beforehand, and adjusting it when co-ordination and communication does not work between the buyer and supplier, is critical in maintaining development speed. Moreover, it helps to curb irritation during the collaboration. This practice was particularly visible at HJH, where the purchasing department monitored the collaboration closely, and to some extent at DAP and PAN. Most companies do have a visible evaluation of technical design aspects and do also evaluate commercial (OMP8) aspects. At BE this occurs in a pragmatic and informal way and does not necessarily result in dramatic problems in the low involvement collaborations. However, in the collaboration with the sensor supplier the reliability was not immediately assured. At PAN and DAP discussions about the cost price and production quantities brought several commercial problems to the surface, which under time pressure can strain the collaboration. The systematic preparation of a collaboration, including discussing different scenarios, can remove some of this strain. Furthermore, few companies jointly evaluated the development performance with the supplier during or shortly after the project. We did notice that DAP tested a tool to determine the right communication structure with the fragrance supplier, although this did not prevent the unclear role of the fragrance consultancy company.

We conclude that companies managing their collaborations based on pro-active and systematic operational processes are associated with high performance. However, low scoring processes are not consistently associated with low performance. This suggests that additional explanations have to be found in the extent to which companies invest in active and permanent strategic efforts to manage supplier involvement and in the presence of driving and enabling conditions.

7.8.2 Cross-case comparison of the Strategic Management of supplier involvement

In Chapter 3 we argued that a company that has invested in a strategic management infrastructure is able to select and set up their collaborations quickly and effectively. In other words, project teams are better prepared at the start. Such companies will also be able to capture additional long-term and strategic benefits from supplier involvement in development projects. In chapter 5 we saw a first empirical indication at Océ that such support was provided and long-term benefits could be obtained within the boundaries of a specific technology or part category. In order to verify our first argument, we measured the overall average scores and subsequently assessed the extent to which these processes did effectively support the project teams in setting up their operational collaboration with suppliers. The scores and assessment are displayed in Table 7.4. third column.

In terms of the overall scores on the Strategic Management Processes, we observe that two companies were particularly pro-active and systematic. HJH scored an average of 4.3 in the strategic management area, whereas DAP scored somewhat lower (3.6) but was pro-active in all listed processes. PAN was clearly trying to be pro-active in its supplier involvement approach but was not yet consistently systematic across all technologies. BE was reactive in strategically managing its supplier involvement.

In terms of the support that the operational projects gained from the strategic management processes in the case studies, we found that several project teams were not able to benefit from a technology that had been pre-developed or from a fully qualified supply base at the start of the project. In contrast to its usual routine *DAP* had not identified and pursued the fragrance modules as a key technology before the development project. The project could therefore not benefit from a technology that had been pre-developed or from a fully qualified supply base at the start of the project. *PAN* was not completely successful in pre-qualifying and pre-selecting suppliers for the generator technology. In the software development the involvement of the supplier was actually based on a knowledge and capacity shortage. However, this was an emergent choice rather than a planned one. In addition, the available guidelines were not completely followed in one of the supplier selection choices and during a comprehensive risk assessment when planning the different collaborations. BE's current supply base is the result of having built up long-standing supply relationships with capable production suppliers for typical commodities. The fact that they are not systematically building up a supply base for future products and technology did not seem to cause any problems in the project with low levels of supplier involvement (e.g. revolving door). However, products with an increasing electronics content depend more strongly on external expertise due to the lack of internal knowledge. The question remains of how BE can better use and find external supplier expertise to improve its development performance when competitors increase the pressure.

In their beverage project, HJH was found to have a high level of support for strategic efforts in developing a competent supply base for involvement in product development. It had established contacts and identified a collaboration opportunity with one of the supplier's subsidiaries using a cross-functional pre-qualification approach. In the fruit sprinkles project, the project team were also able to reap the benefits from its previous strategic efforts to build up a suitable supply base. The project team was able to go through the selection process quickly and without internal commitment or trust problems. The project team in the coffee machine project at DAP benefited from having one preferred supplier at its disposal in the boiler technology area. This explains the low effort that DAP needed to invest in selecting suppliers and determining the extent of involvement. However, unexpected demand created a need for a second supply source, which had not been foreseen by its strategic management processes, and had to be responded to during the project. PAN's sample changer project team benefited from the previous efforts to build a long-term collaboration with a motivated guideway supplier. However, it was not entirely clear at the onset what development and assembly-related activities would be done internally or externally.

In general, we can conclude that companies do clearly differ in their general practices and perspective on managing supplier involvement in both the strategic and operational project management arenas. HJH and DAP, and to some extent PAN, are already actively creating a supplier base for different technological areas that is suitable for use during product development. One of the most direct contributors to effective operational management came from having pre-selected suppliers that were suitable for involvement in product development. This is especially beneficial in development projects with short (or extremely short) development horizons (HJH, DAP). The general scores tell us something about the mindset and the approach (rigor) of the company in leveraging supplier's expertise in product development. However, as we encountered variations for specific commodities, they do not reveal the support that companies actually give to individual collaborations.

We continue by further analysing the extent to which the Strategic Management Processes are associated with prospects of capturing specific long-term benefits from their collaborations with suppliers. In Table 7.5 we can see that it is more relevant and valuable to achieve some long-term benefits for specific technology and part categories (commodities).

Table 7.5 Detailed long-term collaboration results

		Long-Term Collaboration Results		
Company	**Project**	**(1) Alignment of Technology Roadmaps**	**(2) Improved Access t(Supplier's knowledge**	**(3) More effective + efficient future collaboration**
DAP	Vacuum cleaner	2	3	3
	Coffee machine	2	2	3
PAN	Spectrometer	1.25	2	2
	Sample-changer	2	2	2
BE	Speed gate	1	2.5	2
	Revolving door	1	1	1.5
HJH	Carbonated soda drink	3	3	3
	Fruit sprinkles	1	2	2

Companies do not share their product and technology planning with a lot of suppliers. For example, it appears to be less relevant for production or process suppliers. This LTCR score is therefore not expected to be high. Furthermore, we notice that when developing multi-technology parts companies think they will achieve a better access to the supplier's knowledge. For example, at BE the collaboration with the sensor supplier was expected to result in improved access to its sensor knowledge for future projects, whereas this expectation was not strong for the collaboration with the sheet-metal suppliers. This was because BE started using supplier technologies that it had not used before and the supplier was willing to continue providing this knowledge to BE. Moreover, collaborations targeted with higher involvement provided more opportunities for learning experiences (DAP fragrance module and boiler development; BE sensor development; HJH beverage development).

This raises the question of the extent to which these companies are prepared to exploit the potential long-term benefits in future collaborations and to transfer experiences and parts to other parts of the organisation. If we zoom in further on the differences in the Strategic Management Processes and scores on the long-term benefits between companies, we note that DAP and HJH had the highest scores. BE and PAN expected these benefits to a lesser extent. PAN expected to capture most of the benefits in one of the four collaborations. The HJH cases demonstrate that it displays a systematic care and attention for continuous learning and adaptations of decision-making processes related to supplier involvement. We observe specifically that, compared to other companies, HJH scored substantially higher on the evaluation of guidelines and the supplier base, and on the evaluation of the development performance of suppliers within projects. HJH's evaluation practices at strategic and operational project level ensure that learning experiences are made explicit and can be taken on board as action points for future collaborations. By evaluating its guidelines, HJH is able to transfer some of its local experiences and knowledge into helpful ways of working that are accessible to the broader organisation. Finally, the evaluation of the fit of the supply base with the overall technology and product development and manufacturing outsourcing policy is strongly emphasised by the purchasing department and receives support from different managers involved in product development and dealing with suppliers. At DAP and PAN commodity strategies are developed and reviewed from time to time. However, joint evaluations with suppliers did not take place immediately after the project was finished, nor were future projects immediately identified. This reduces the chance of capturing the efficiency benefits in future collaborations. DAP is clearly working on developing guidelines for improving the communication and the role of suppliers, and this should benefit future collaborations. BE does not have a strong integrated strategy and operational management for supplier involvement, which reduces its ability to substantially improve designs and exploit supplier innovations in new projects. In conclusion, HJH and DAP appear to be generally better equipped to capture the long-term benefits than the other companies.

The current picture of high and low performing projects is not completely explained by differences in levels of Strategic and Operational Management processes. HJH's pro-active and systematic routines do not automatically lead to the conclusion that less systematic processes result in off-target performance, since DAP, PAN and BE also have projects that meet most of their targets. We therefore need to further examine the levels and role of enablers and drivers in supporting the effective management of supplier involvement.

7.8.3 Cross-case comparison of enabling conditions

We now continue to analyse the presence or lack of conditions that inhibited or facilitated the companies in taking critical decisions and manage the collaboration. Studying the highest and lowest scoring enablers in more detail (Table 7.6), we found that especially HJH, and to a large extent DAP, have been investing in a cross-functional organisation and the participation of the purchasing department in product development and in strategics is secured. Multiple internal functions are counterparts in discussing the input and issues in different types of collaborations with suppliers. The qualities of human resources also receive a high score.

Table 7.6 Overall scores on enablers

High scoring enablers (average; range)		**Low scoring enablers**	
Cross-functional organisation	**2**-3	Project management capabilities	1-2
Quality of human resources team	**2**-3	Project team stability	1-2
Supplier technical capabilities	**2**-3	Compatibility of culture/ operating style	1-2
Mutual Trust	1-3		

At BE we observe that there is no true, early and extensive integration of these two departments. Furthermore, both in terms of the structure and knowledge level, the R&D and purchasing departments do not jointly identify opportunities or discuss future plans for involving suppliers in product development. At PAN we can see the set-up of a cross-functional organisation to officially integrate R&D, Purchasing and Operations. However, early involvement of the purchasing and manufacturing departments in the project teams at PAN did not guarantee a proper risk assessment for all planned collaborations in the spectrometer project. The cross-functional collaboration and quality of human resources at team level generally scored highest at HJH followed by DAP and PAN, with the lowest score at BE. With regard to the collaboration enablers, we found that a number of companies scored highly for *suppliers' technical capabilities, collaboration experience* and *compatibility in operating style and trust*. However, as in the Océ case study, the initially low levels of trust had to be worked on during the collaboration. High scoring enablers have allowed companies such as BE and HJH to co-ordinate development activities easily with their suppliers. In small companies, and where there is a low extent of supplier involvement, these enablers can partially compensate the reactive decision-making, which explains some of the results at BE. When analysing lower scoring enablers, it turns out that project management capabilities were not well assessed in advance of projects. The importance of this capability is underlined by the unexpected problems in meeting deadlines or the need to take over the co-ordination with second tier suppliers (DAP).

In general, we expected companies that intended to ask for a significant level of supplier involvement (based on global specifications or higher) to measure the ability of the supplier to set up and manage its development projects with customers based on systematic planning and budgeting tools. However, practically none of the companies measured the project management capabilities of suppliers extensively. The most successful companies stated that this capability 'emerged' through the overall impression of how the supplying company presented itself in terms of its organisational structure and way of working. The availability of guidelines that describe decision-making and other processes increases the confidence before starting the collaboration, however, it is only through actual collaboration experience that their true ability is revealed. A closely-related topic is the compatibility in the specific styles of decision-making and daily operation. Does the direct pragmatic approach fit well with the internal way of working and with the culture? Some companies suggested that customers themselves may need to adjust their usual business methods because of the supplier involved (think for example of a large OEM company collaborating with a very small supplier). This 'fit', that was emphasised more than once by HJH, will positively influence the collaboration.

7.8.4 Analysing the impact of business unit, project and collaboration drivers on processes

We now continue by investigating whether factors indicating different levels of uncertainty, novelty and complexity have actually been addressed with an appropriate level of active execution of strategic and operational management processes to address the related risks (see Table 7.7). We therefore investigate possible mismatches in the way that the companies anticipated or addressed these risk factors. Our basic hypothesis is that high levels of driving factors require more pro-active, systematic and adaptive processes to mitigate the risks.

When analysing the business unit drivers, we found an initial indication that size differences may point to differences in the need for explicit guidelines. BE, a relatively small company, adopted fewer explicit guidelines for supplier involvement and still had on-target performance; this matches our expectations due to the low organisational complexity to co-ordinate different activities (ceteris paribus). This occurred to some extent in some of the other collaborations, and is therefore in line with our expectations. However, this only seems to occur if particular collaboration enablers can partially compensate for the lack of systematic execution of co-ordination processes. These enabling conditions are a long, shared history of collaboration between relatively small organisations, sharing a similar informal, pragmatic culture. We also found that particular conditions put extra demands on a more systematic and intensive execution of certain Operational Management Processes. We therefore argue that a small company still needs some degree of proactive planning of collaborations.

Table 7.7 Overall scores on driving factors

Company	**Project**	**Drivers (1= low; 2 =medium; 3 = high)**		
		Business Unit Drivers	Project Drivers	Collaboration Drivers
DAP	Vacuum cleaner	**2**-3	3	3
	Coffee machine		2-3	2-**3**
PAN	Spectrometer	3	1-3	3
	Sample-changer		1-3	1-**2**
BE	Speed gate	**1**-3	3	3
	Revolving door fullview		1-3	1-2
HJH	Carbonated soda drink	3	2-3	2-**3**
	Fruit sprinkles		1-2	**1**-3

At business unit level, we noticed that industry differences in terms of the production type affect the type of suppliers involved and that the content of specific strategic management and operational processes will therefore differ. HJH is a company active in the food processing industry where product architecture does not have the same connotations as in discrete assembly industries. This does not mean that the basic planning steps do not occur. However, the processes will use different terms that are typical for that industry. For example, the extent of supplier involvement is also differentiated but not in terms of functional specifications, global design, detailed design and technical specifications. Furthermore, the trend towards sourcing modules from suppliers is not applicable in the food processing industry. In addition, the technological focus will typically not be on production technologies and design disciplines that are typical for high-tech industries. For example, in the food industry no mechanical engineering, electronics or optics engineering and production suppliers are typically involved, but rather food packaging, flavour, filling and ingredients suppliers. Some issues therefore need to evolve differently. However, we found that the basic cycle (planning, executional and evaluative processes) of managing supplier involvement in a development project holds in all the contexts studied; the strategic management cycle is also equally important in all contexts.

We now analyse the performance differences between highly and less innovative projects, one of the key drivers at project level. It appears that highly innovative projects achieved the worst time performance, while product quality both exceeded initial targets and under performed them. In other words, the risks are higher. What can explain the results is the way that companies planned and prepared supplier involvement in the different projects. We therefore made an explicit distinction between the operational planning processes (OMP 1-6), the executional processes and the evaluation processes. Comparing the highly innovative projects (projects with serial number 1) and less innovative projects (projects with serial number 2) with regard to these processes results in the following table.

Table 7.8 Operational Management Processes in highly vs less innovative projects

	DAP 1 (HI)	PAN1 (HI)	BE 1 (HI)	HJH1 (HI)	DAP 2 (LI)	PAN 2 (LI)	BE 2 (LI)	HJH 2 (LI)
Average score Project results	2.50	1.25	2.00	2.25	2.00	2.25	2.00	2.00
Average score OMP 1-6	2.7	3.2	2.2	3.7	2.7	2.7	1.8	3.8
OMP1: Determining project-specific develop-or-buy options	4	4	2	4	4	4	2	4
OMP2: Suggesting alternative suppliers/technologies/components	2	3	3	4	1	2	1	3
OMP3: Selecting suppliers for project involvement	2	3	2	3	2	1	2	3
OMP4: Determining timing and extent of involvement	2	3	2	4	2	3	2	4
OMP5: Determining operational targets and work package	3	3	3	4	4	3	3	4
OMP6: Designing communication interface upfront with various suppliers	3	3	1	3	3	3	1	5

The processes on average score higher in the highly innovative projects than in the less innovative projects for three out of the four participating companies. Only at BE were the process scores on average equal in both projects. This would support the idea that in highly innovative (HI) projects the planning processes are carried out to larger extent than in less innovative (LI) projects. These differences in process activity should be related to the project results (product quality, product cost, development cost, and development time). Analysing Table 7.8, we do not find a consistent pattern between the average management processes score and the project results. High scores on processes in both highly and less innovative

projects do result in high project performance for HJH. This is in line with expectations. In contrast, PAN received somewhat lower process scores in the highly innovative project, resulting in low project performance. This suggests that it had insufficiently detected and addressed the risks associated with involving these suppliers in a highly innovative project. At DAP and BE, low scoring processes for the HI project resulted in reasonable project performance. However, at BE the project results showed underperformance on product cost.
If we look at the processes individually, when alternative technologies, components and suppliers are suggested (OMP2) this clearly scored higher in the HI projects than in the LI projects for all companies. This makes sense, given the need to develop new parts that require alternative solutions to be considered and therefore alternative suppliers. Note however, that this is not statistically underpinned: a sample of eight is too small to draw acceptable conclusions. We need to add that low scores on supplier selection and determining the extent of involvement, for example, may receive less attention when a supplier has been pre-selected and has been involved before. This means that the supplier's capabilities are known, thus reducing the need to pay pro-active attention. This may hold for both highly and less innovative projects. At BE we can argue that its operational processes relied on informal project-driven needs, which works well for the technology ratios typically present in their core business revolving door products. Introducing a higher electronics content in their products requires more intensive communication on work package definition and target setting because of the relatively lower internal familiarity compared to other 'typical products'. At DAP, projects that required collaboration with a supplier in a new technological area resulted in an upward re-adjustment of target part cost. This underlines the importance of jointly determining targets and keeping the work package realistic when a project uses new technology.

Another driver that can explain the relative success is the *level of supplier involvement* that project teams adopt. Typically, projects with low levels of involvement do not need to execute the operational management process cycle so intensively. This does not mean that different planning, execution and evaluative activities are not helpful in managing the collaboration. However, the development does not need high levels of co-ordination between tasks, for example, because it only provides manufacturability suggestions. This means that the concept and a lot of specifications have already been generated. Projects targeting more suppliers that work with higher levels of involvement certainly require careful planning in advance to find the appropriate suppliers. Moreover, more effort is needed to co-ordinate the development work with and between suppliers, to make sure that the parts they are working on function and fit properly when integrated. Projects at BE typically have lower levels of supplier involvement, while projects at HJH and DAP typically have higher levels. In line with previous findings, we observe that lower levels require less co-ordination (Wynstra and Ten Pierick, 2000; Sobrero and Roberts, 2002). In the low-complexity and low supplier involvement cases, high collaboration enablers can partially compensate for the lack of systematic execution of Operational Management Processes. If more novel parts/technologies are introduced, the associated higher project risks increase the need for systematic processes for decision-making, and earlier and more intensive co-ordination of development activities with the supplier.

Finally, we found empirical cases showing that the limited availability of suppliers at the start of the project increases the need to suggest alternative technologies, components and hence alternative suppliers. For example, PAN was dealing with a small number of monopolistic suppliers who suggested the need to identify alternative technologies and possibly alternative suppliers. The ability to suggest alternative technologies is also strongly influenced by the specific product performance levels and the product architecture chosen. In the case of DAP, the unexpected surge in demand resulted in increased attention to selecting a second supplier for the boiler.

Having analysed the results of highly and less innovative projects, we have learnt that a development project is faced with different sources of risk. Less innovative projects tend to perform well even with lower scores on the six operational planning processes. However, introducing new product and/or manufacturing technologies or a new product architecture leads to technical and co-ordination problems. In such highly innovative projects, well-performing companies effectively detect and address such risks by properly selecting a supplier and setting up the collaboration. Moreover, the average *'level of supplier involvement'* is suggested as a possible indicator of the need for pro-active and systematic planning and co-ordination of collaborations with suppliers. Finally, the limited availability of suppliers increases the need to suggest alternative technologies, components, and hence alternative suppliers.

7.9 Comparison with Océ findings and implications for the framework

We encountered substantial differences in the practices of designing and implementing supplier involvement in the five different companies. HJH and DAP have built an organisation that enables them to effectively involve suppliers in development projects. This does not mean that these organisations do not encounter problems and risks that need to be addressed when developing new products. However, in terms of the processes and enabling conditions we observed a more pro-active attention and structured approach to bringing in the relevant supplier expertise in the design of the end product.

Similar to our findings at Océ, we found that the initial six Operational Management Processes are key managerial planning processes within development projects. What appears to matter is how companies find capable suppliers and consciously design and fine-tune the content of the type of assignment required and the collaboration process with their suppliers. If executed systematically enough, they are able to detect and address risks causing the mismatches between the expected and actual supplier contributions and the resource-consuming co-ordination of different development activities. Insufficient and ad hoc attention to these activities allows collaborations to start off on the wrong foot, resulting in technical and commercial problems. We noticed that in successful companies small groups of people within the project team are engaged in setting up and fine-tuning the collaboration together with the supplier in terms of the assignment, targets and communication structure. Before they can start they first have to take a number of decisions that result in the selection of a supplier who is able to fulfil the desired role in development. In these processes, the project leader, and possibly the project buyer, first define and analyse the overall product architecture in order to identify which parts are candidates for outsourcing. Alternative technologies and suppliers are then considered and selected, and the moment and extent of supplier involvement is determined. This suggests that development teams need to keep an overview of various collaborations in relation to the overall product design and project objectives. In fact, we can distinguish, on the one hand, between the planning, co-ordination of the portfolio of collaborations with suppliers and integration of their contributions and, on the other hand, the set up and management of individual collaborations.

In terms of the key Strategic Management Processes we found that, similar to our findings at Océ, pre-selection is critical in supporting the operational management of suppliers in projects. In the power supply case at Océ, pre-selection was extremely helpful in speeding up decision-making but also in accessing the supplier's knowledge in advance of development projects. At HJH and DAP the benefits of decision-making speed when pre-selecting appear to be even more valuable given the relatively short development horizons of their projects. Furthermore, the cases studies (DAP and HJH) demonstrate the importance of the interplay between having guidelines for supplier involvement and the actual decision-making and actions of representatives involved.

If we consider the key processes to obtain long-term benefits of supplier involvement, we observe that a company such as HJH is likely to improve its development performance with suppliers because it is equipped to learn and to adjust the way it collaborates with them. Furthermore, we notice that obtaining the fruits of improved access to a supplier's knowledge base and aligned technology roadmaps is based on focused efforts by the buying company to create collaboration (motivation) and information exchange within and outside specific collaborations (HJH and DAP). Focused efforts means selecting the key technological areas in which it chooses to be dependent on the knowledge of suppliers. In that respect using a commodity structure and strategy has helped Océ to successfully access and exploit supplier expertise for their power supplies. However, fewer successes were achieved in other areas.

Analysis of the critical conditions suggests that both project and collaboration drivers and enablers are initial indicators for a number of risks that can undermine the efficiency and effectiveness of the collaboration. The introduction of new technologies, concepts and new suppliers, or any combination of these, into a project constitutes particular risks to the success of the collaboration. We found that collaboration enablers can be real barriers or strong facilitators of the actual collaboration in the project. Being aware that both parties do not have a history of collaboration or are used to working with different decision-making styles (e.g. responsiveness: late communication of delays) should trigger pro-active attention at the start of the collaboration. The planning processes are especially critical, such as determining what capabilities, resources and communication interfaces are required to provide the desired contribution and in the light of the target setting. The 'Cross-functional orientation between Purchasing and R&D' at both general organisational and project team levels also affects the effectiveness of planning and co-ordinating the portfolio of collaborations with suppliers (e.g. decision-making during supplier selection and assuring a balanced trade-off between commercial and technical development objectives).

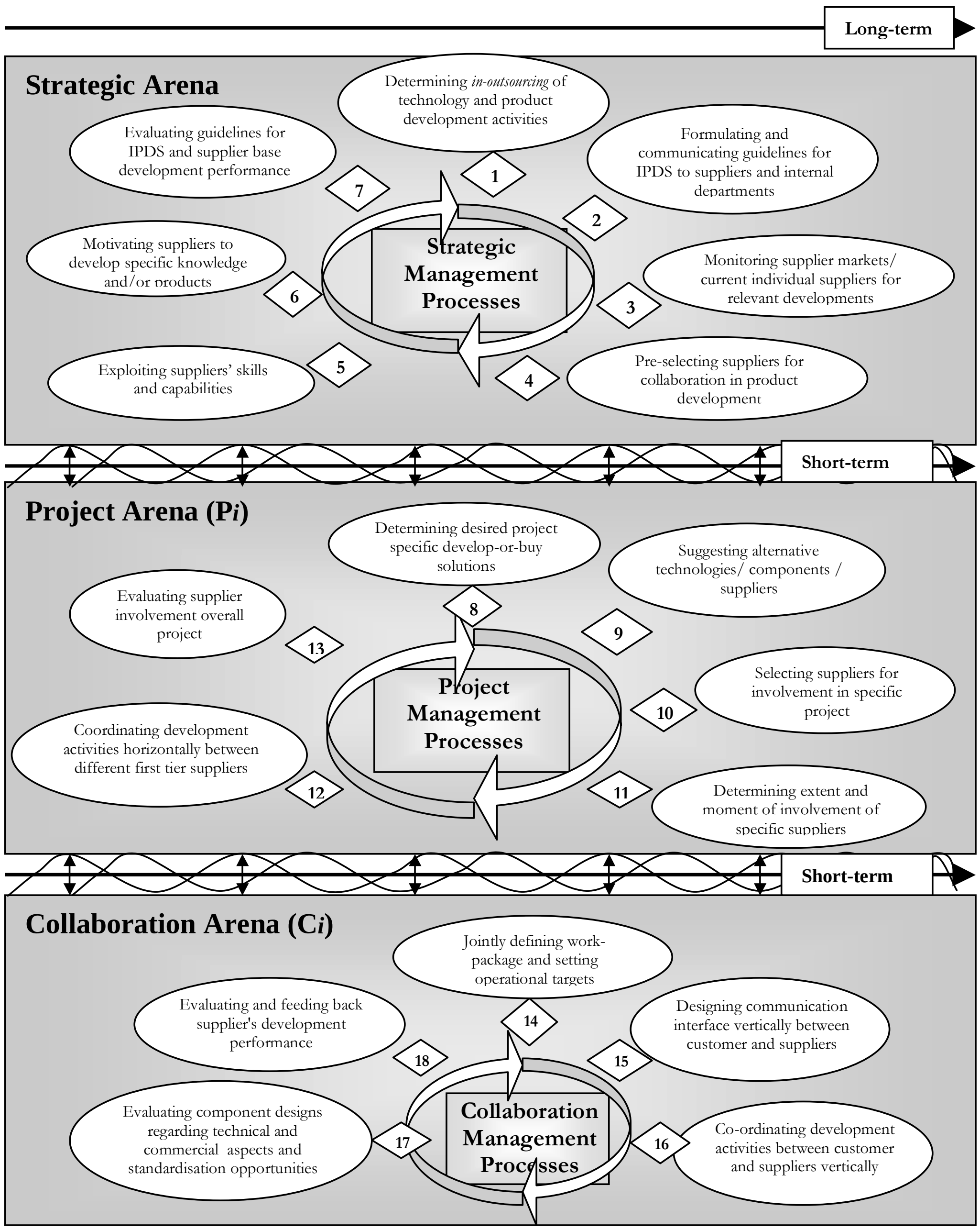
Many case study companies argued that it is impossible to foresee all risks in advance. This underlines the importance of creating a flexible and learning organisation. The cases taught us the importance of evaluation as a visible mechanism for determining the need for adaptations in policy, guidelines and supply bases. At HJH, different evaluation processes took place at different levels, making sure that they provide useful input to higher-level long-term decision-making. Evaluation efforts strengthened their ability to reflect and jointly learn with suppliers from collaborations and to capture long-term benefits. In that respect, the visible cross-functional organisation at the strategic, project team and collaboration level has proven to be a critical enabling condition for effectively managing supplier involvement. We note that, in addition to the structural organisation that supports true cross-functional collaboration, this is the result of investing years in creating conviction and trust among key players.

7.9.1 Framework adaptations

In terms of the conceptual adaptations of the framework, these insights lead us to argue that effective supplier involvement requires management in an additional arena, namely the management of collaborations with individual suppliers. An 'arena' is a 'sphere of activities' (Oxford Dictionary). Distinguishing three different, though interrelated, managerial arenas improves our ability to study the management of supplier involvement: the *Strategic Management* arena, the *Project Management* arena and the *Collaboration Management* arena. Each arena contains a cycle of processes that is characterised by their planning, executional, and evaluative nature. The distinction between project and collaboration management hinges on the fact that project teams are working with a portfolio of collaborations to achieve overall project objectives. Some decisions are therefore taken with this overall product design and the overall project objectives in mind. As soon as the suppliers and type of collaborations have identified, the next level of management becomes important, i.e., the development of the specific part; this requires a series of collaboration management processes. For example, the Operational Management Processes (5, 6) are highly collaboration-specific and interactive. They concern 'setting up the actual collaboration in terms of defining the targets and the exact task division' and 'designing the communication interface with suppliers'. Similarly, vertical co-ordination with a single first tier supplier and its second tier suppliers is usually collaboration specific. However, each single contribution must be integrated. The interdependencies of the modules require project management, for example in terms of co-ordinating development activities between the *different first tier* suppliers. We also propose to introduce a separate evaluation process within each management arena. The importance of effective evaluation routines in different managerial arenas was demonstrated in the HJH case. Strategic evaluation of the current supplier base and the evaluation of guidelines differ from project-based supplier involvement evaluation. Both also differ from the joint evaluation of development performance with individual suppliers; they are interrelated, however.

At strategic level the supply base is also evaluated in relation to the past performance of projects and individual suppliers, but is complemented with information on external technological developments and possible changes in future product needs. The strategic level can also refer to strategies developed by companies for specific part groups such as 'commodities' and 'technology categories'. At project level the evaluation can be focused on the performance of various collaborations and the internal decision-making and co-ordination processes. As such, it uses the evaluation information when the buyer and supplier evaluate their collaboration. However, the use of such evaluation information also supports future collaborations with this specific supplier. These proposed adaptations require some of the Operational Management Processes to be transferred to the Collaboration Management arena. In Figure 7.19 the three management arenas and additional processes are depicted.

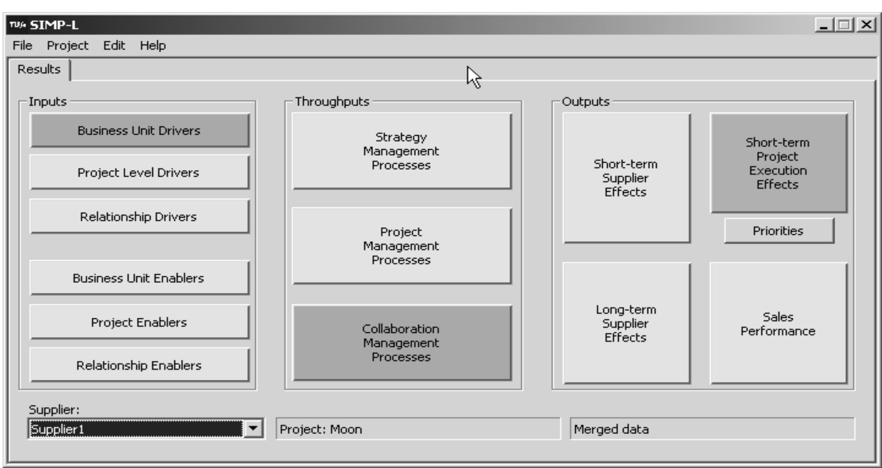
Figure 7.19 Managing supplier involvement through three interrelated management arenas



7.10 Reflection on the usability of the framework as an instrument for diagnosis

So far, we have used the framework to analyse the results, processes and conditions in a small number of companies that involve suppliers in their product development processes. We have developed tentative insights into some of the factors and processes that appear to underlie successful and problematic collaborations with suppliers in product development. However, causal relationships have not yet been underpinned with sufficient statistical evidence; neither are companies themselves able to detect well and underperforming processes and conditions in their own organisation. We therefore decided to start a dual trajectory. We set up a survey project in the US and sent the pre-tested questionnaire used in the case studies to over 500 companies from different sectors. The results were unfortunately not available in time to be included in this thesis but, when available, will be used to further improve the framework and will be published in forthcoming articles. In addition to conducting a survey, we wanted to improve the accessibility and usability of the framework as an instrument for (self) diagnosis. Our objective was therefore to investigate whether companies themselves can detect and distil useful information on well and under performing managerial processes and conditions using a diagnosis instrument. We therefore used object oriented programming to transform the initial questionnaire into a computer aided diagnosis tool. We used the specific experiences and feedback collected during the completion of questionnaires and the first roundtable meeting with participating companies as a starting point for the first design of the diagnostic instrument. The interface of the diagnostic instrument with the end-users is displayed in Figure 7.20.

7.20 User-interface diagnosis instrument



This instrument enables companies to look retrospectively at product development collaborations with suppliers. Companies can review and evaluate a specific collaboration with a particular supplier or groups of suppliers in terms of the additional long-term benefits expected from this collaboration. The instrument helps them to find potential sources of explanations for a particular (supplier) performance level. By scoring questions for results, processes and conditions on pre-determined scales, an end-score is calculated for every box, as shown in Figure 7.20. This score causes the box to turn a certain colour (red, yellow or green). The end-users can later ask for a more detailed overview of the results.

We distinguished between three sets of questions to assess how active the company was in carrying out various processes in the strategic, project and individual collaboration management arenas. This allowed companies to closely assess the way they managed the collaboration of up to five individual suppliers. The scores are given one of the three possible colours to show whether they have been *sufficiently* carried out. As input to determine the colour of the process, we use the scores of the driving conditions as a correction of the standard scores of the processes. Higher scores on driving factors will make it harder for companies to get a green coloured process. This is based on the assumption that higher levels of complexity, novelty and uncertainty in the environment in which supplier involvement takes place means that a company must increase its level of attention to manage supplier involvement in order to address the risks and achieve its quality, cost and time targets. Although these relationships have not yet been supported by large scale data, pending the results of the survey, we found enough indications that overall they do affect the minimum levels of attention See Appendix 7.5 for a more detailed description of the instrument development. The user manual and instructions for the actual instrument are provided in Appendix 7.6.

The case studies and presentation of the instrument resulted in the following feedback. The scores on the results, processes and conditions provided a more integrated picture than was previously available to most of the company representatives. For example, PAN now realised which risky conditions they had underestimated, and that their pro-active managerial processes were insufficiently carried out to detect and address them. Introducing new suppliers into an innovative project with complex modules requires a sufficiently in-depth assessment of whether these conditions introduce an unacceptable risk of project delay and development costs. For HJH, it was a confirmation of years of hard, conscious work on introducing and improving collaborations with suppliers. Moreover, the instrument allowed multiple comparisons between internal actors (e.g. buyers and R&D) to be held. The differences in assessment on specific processes can result in focused discussions between the two departments to clear up the differences. Although the instrument was not originally intended for suppliers themselves to answer questions, some companies particularly like the idea of having a mutual assessment of certain questions. HJH made observations that even in a low-performing project, high performing suppliers can be detected. Giving credit to the performance of a supplier can strengthen the development of a long-term relationship with a motivated supplier. Suppliers usually only hear from the buyer when things are not running smoothly (although the instrument can and should also be used the other way around). Besides its use as an evaluation instrument, the instrument may also be useful in 'designing' new projects. Some companies were interested in its use at the start of a project as a risk detection instrument by assessing and discussing the presence of the driving and enabling conditions. None of the companies have actually used it yet before starting a project. The instrument can also support process improvement related to the long-term strategic management of supplier involvement. In addition to the direct conditions, people can determine whether they have invested sufficiently in creating a motivated supplier or whether they have a committed policy of taking existing supplier capabilities or products as a starting point.

In addition to the feedback on the results of the analysis and the instrument itself, companies also came up with a number of areas for improvement. Besides indications of good or under-performing processes, companies desired additional guidelines as to what steps they could take in each of the processes. We therefore developed an additional maturity scale for each of the processes, building further on the five-point assessment scale used in the case studies (see Appendix 7.7). Some respondents from HJH experienced problems in understanding what specific terms meant in their product development context. For example, the term 'product technical performance' was better understood if 'product quality' was used. When assessing product quality, the respondents were considering indicators such as 'taste' and 'appearance' instead of functional performance, reliability and durability indicators. It appears that the initial terminology was only applicable to a process-based industry context. The wording in the questionnaire therefore needed to be altered. Furthermore, the instrument does not take into account how stringent targets are. In this way, an organisation may not be challenged enough and may become complacent in improving its processes. The instrument is still in the testing phase, but the first feedback has been positive. The tests should further ascertain that useful and valid alerts appear when representatives evaluate their processes in the three management arenas and the driving and enabling conditions.

7.11 Conclusions

Having improved the analytical framework using the embedded case studies at Océ, we wanted to test its robustness and therefore apply the framework in different contexts. Our second aim was to transform the analytical framework into a diagnosis instrument by which both researcher and companies would be able to diagnose the management of supplier involvement. The output was a computer supported diagnosis instrument allowing companies to detect the successful and problematic processes and conditions that underlie these results.

Having examined eight development projects in four different companies, we developed five major insights regarding the management of supplier involvement in product development. *First*, applying the current framework revealed that successful companies, in terms of short-term results, have been able to develop coherent and systematic routines in decision-making and preparing projects with a supply base, policies and guidelines supporting decision-making in the operational project arena. Smaller companies and projects with lower supplier involvement have been able to achieve their targets due to longstanding and trusting relationships with their suppliers and informal communication mechanisms. *Secondly*, the diagnosis can be strengthened by assessing decision-making processes and activities in three management arenas: in the long-term 'Strategic Management Arena', in the short-term operational 'Project Management Arena' and finally in the individual 'Collaboration Management Arena'. By clustering different planning, executing and evaluative processes in these three arenas, we improved the logic of the analytical framework. *Thirdly*, we found that the framework confirmed the critical role of analysing the conditions for supplier involvement in advance of the project. Going through a systematic series of planning steps defining the area of collaborations, selecting a capable supplier cross-functionally and jointly determining with the supplier the exact task division and targets to be met, together allow the detection of risks that could undermine the collaboration. The processes identified ensure that collaborations do not start off on the 'wrong foot' in terms of mutual expectations regarding contributions and tasks or in terms of inappropriate communication mechanisms. *Fourthly*, we found that successful companies that truly exploit their suppliers' expertise in different technological areas are strongly engaged in pre-selecting suppliers in such a way that their capabilities are known and accessible to development teams. The fruits to be reaped appear in the form of reduced effort in the supplier selection process and fewer misunderstanding by making expectations about each other's contributions and output more explicit at the start. *Fifthly*, we found evidence that capturing the potential long-term benefits of supplier involvement depends on the extent to which the organisation is prepared to learn from them and allow future collaborations to take place with suppliers. Building evaluation routines in each managerial arena allows long-term interests to be balanced with short-term pressures, as it channels learning experiences for the benefit of collaboration with a supplier the next time. The usefulness of the instrument to both companies and researchers was demonstrated by its integrated assessment of results and the processes and conditions by which they are partially generated. The tool can be used in multiple ways both during preparation and as an instrument to aid learning from past projects with supplier involvement. It allows potential sources of problems to be located more precisely in the three managerial arenas and the focus of improvement to be determined.

The next chapter focused on developing additional knowledge about the process and the conditions for pre-selecting suppliers for involvement in future development projects.

Chapter 8
Developing a collective frame of reference for determining supplier contributions to product development

'Unclear supplier visions could lead to a situation where ideas from suppliers are not considered as important'
(Nellore, 2001)

8.1 Introduction

So far we have developed an integrated framework for studying the management of supplier involvement in product development. Follow-up case studies at four companies in different industries allowed us to apply the framework in different contexts and to transform the framework into a diagnostic instrument for results and managerial processes and conditions underlying effective supplier involvement. The diagnostics helps us to understand which processes and conditions are problematic and why certain short and long-term collaboration results are achieved. The case studies revealed that companies that have invested strategically in creating a capable supplier base in advance of a specific development project have a head start when involving those suppliers in product development within projects. We found that development teams that proactively and systematically pre-selected suppliers and evaluated their performance were better able to define the areas of collaboration with suppliers, to select capable suppliers, and to set-up the various operational collaborations. In this chapter we go one step further and try to answer the second part of the fifth and last research question: 'How can a [revised] analytical framework be applied as a reference model for improving processes for managing supplier involvement?' We continued our research collaboration with Océ through an action research project aiming at developing specific guidelines regarding how to carry out one of the key managerial processes: '*pre-selecting suppliers for future involvement in product development*'.

The chapter is structured as follows. We first discuss the general research methodology adopted. We then explain how one of the subjects of improvement, i.e. the selection of the key managerial processes, was executed and what the underlying motives were. In the remaining sections, we describe the process of creating the discussion among, and analysis of the process by, Océ representatives. We demonstrate how this has helped them to begin overcoming an internal barrier in jointly determining what contributions are needed from suppliers and what Océ must do to enable the supplier to provide the requested contribution. Finally, we integrate the findings of this chapter/action research project with the insights developed in previous chapters.

8.2 Action research methodology

The action research adopted in this study is appropriate when the research question relates to understanding the process of change or improvement in order to learn from it (Coghlan and Brannick, 2001). What characterises action research is that it is interventional, participative and interactive in nature. According to Coughlan and Coghlan (2002) the central idea of action research is that it uses a scientific approach to study and bring about the resolution of important social and organisational issues (interventional), working together with those who experience these issues directly (participative). A variety of modes of 'inquiry' (interaction) allow this intervention and participation to take place. They range from 'pure', 'exploratory diagnostic' and 'confrontive' inquiries' (Schein, 1999 citing Coughlan and Coghlan, 2002). Each mode can be more or less useful depending on whether the objective and context pose any practical barriers (such as constraints by the participating organisation on time or resources, or specific policies hindering an intensive action research project). The possible benefits of, and opportunities for, using different forms of inquiry must therefore be consciously weighed up and selected. In our case we adopted a combination of an exploratory and confrontive inquiry. A confrontive inquiry is where the action researcher challenges others to think from a new perspective by sharing his ideas with them. The ideas might be related to the process and/or the content (Coughlan and Coghlan, 2002). In the project at Océ, our case has performed to some extent as a learning history; knowledge and joint analyses have been fed back to participants as to promote reflection and learning in the organisation on the selected issue.

Although action research projects are typically situation specific and do not aim to create universal knowledge, action researchers must generate implications beyond those required for action or knowledge within their project. At the end of this chapter we intend to extrapolate to other situations, and to identify how the action research project could inform similar organisations, similar issues and so on. The main benefit is that action research has the potential to generate an 'emergent' theory. The theory emerges from a synthesis of the results of the data and a practical implementation of the body of the theory, which informed the intervention and research intention.

A key concern with action research projects is the lack of impartiality on the part of the researcher. As action researchers are engaged in the shaping and telling of a story, they need to consider the extent to which that story is a valid representation of what has taken place and how it will be understood; it should not be biased. In this chapter we try to open up the action research black box by explicitly stating the considerations for adopting particular viewpoints by the participants and the action researcher and what learning experiences have visibly taken place.

8.3 Improving the process for pre-selecting key suppliers for future involvement in product development

8.3.1 Choosing the managerial process to be improved

Having applied and improved the IPDS-framework in the previous four chapters, we needed to select the key process(es) that would be the subject of improvement through action research. Selecting the key issue to be addressed in action research is an important starting point (Coughlan and Coghlan, 2001; 2002). We started this process in March 2002 in collaboration with the steering committee at Océ. We reconsidered the issues and problematic processes that were revealed in the analysis of the case studies at Océ and the other four companies.

Océ and most companies studied have a track record of creating opportunities for suppliers to provide feedback on design aspects during the later stages of product development. However, the management of more intensive collaborations in multi-technology types of parts has proven to be a greater challenge. New areas of opportunity and possible new suppliers were often sought in an attempt to achieve better development performance levels. Earlier attempts to set-up collaborations in various new functional and technological areas have been characterised by increasing internal and external resource costs (co-ordination costs and engineering hours), as the supplier has not been able to provide the expected contribution to the development of the part. Moreover, these collaborations were preceded by an unbalanced involvement of different key parties in selecting and defining the specific extent and areas of supplier involvement. Once a specific supplier had been chosen, the collaboration was often accompanied by substantial internal discussions and doubts at different levels in the organisation. Given the mismatch in the expected and actual supplier contributions, we argued that the conditions for a supplier to provide the desired contribution in development have not been sufficiently created and verified through Océ's strategic, project and collaboration management processes. The result is that Océ has not optimally benefited from searching and pre-selecting key suppliers for involvement in multiple development projects. The steering committee recognised the ineffectiveness of the selection process for a number of non-routine parts. It confirmed that Océ tends to react strongly to short-term setbacks in new collaborations, blocking further momentum to expand the collaboration to other projects and improve the development performance. As we concluded in chapter 5, Océ indeed needs a more strategic, permanent and consistent approach to building valuable supplier involvement collaborations. These insights led us to define an initial area of improvement: *'How can Océ identify and choose the type of added-value in product development it wants to obtain from suppliers in future projects and find the right key suppliers'*. In other words, Océ was interested in how to create a sustainable improvement in the way it determines the areas of collaboration and the type of supplier partners to be selected beforehand. We agreed that this question was most strongly related to how Océ could improve the managerial process of pre-selecting suppliers for involvement in future product development. This process is linked to the strategic management arena of supplier involvement in the IPDS framework, as highlighted in chapter 6, pages 5 to 9.

8.3.2 Designing /setting up the action research

We decided to set-up a cross-functional project team that would actively engage in discussions related to the four research questions. The following representatives[1] participated in this team: *the Purchasing Project Manager, Mechanical Engineering Manager, Manufacturing Unit Manager and Electronics Engineering Manager.* The role of the researcher was to function as a facilitator and a sounding board for the project team representatives, by bringing in experience, knowledge and methods available from literature and previous research at Eindhoven University. In the end, the researcher was also expected to be the integrator of the knowledge and insights and to translate them into a methodology that could be used in support of decisions in the pre-selection process. Steering committee meetings were held every four months, and the project team met every month. See appendix 8.1 for an overview of these meetings. We created an orientation phase during which the steering committee and the project team formulated underlying research questions to improve our joint understanding of the pre-selection process.

- *For which parts of its future printers does Océ want to use the expertise of suppliers to a greater extent?*
- *What are the different desired supplier types and roles that could be fulfilled in the product development process?*
- *Which criteria should key suppliers meet to play that desired role?*
- *With which key suppliers would Océ like to cooperate in future projects?*

We also determined the order in which to answer the questions before developing guidelines supporting the pre-selection process and carrying out any planning. First, in order to be able to find and choose the suppliers to be involved in future product development, we argued that a good starting point would be to agree on a typology of different types of suppliers with clear capability profiles. The identification of 'opportunities for supplier involvement' in terms of important technology and part categories could then be addressed. This would mean analysing existing and possible new commodities and technologies and discussing the desired supplier type/contribution in development. The project team would then be able to assess current and potential suppliers and match them with the desired supplier profile for this type of involvement. Going through these phases and systematically describing the steps and pitfalls we experienced as a project team would represent a significant effort toward providing valuable guidelines for pre-selecting suppliers. This line of reasoning was captured in the action research plan (see Table 8.1).

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[1] During the period from June 2002 to July 2003 a number of changes occurred in the team composition.
First team composition (from 24th April 2002): Purchasing Project Manager, Mechanical Engineering Manager, Manufacturing Unit Manager, Electronics Engineering Manager;
Second team composition (from June 2002): Purchasing Project Manager, Mechanical Engineering Manager, Manufacturing Project leader, Electronics Engineering Manager;
Third team composition (12 December 2002 onwards): Vice President Purchasing, Purchasing Project Manager, Mechanical Engineering Manager, Manufacturing Project leader, Electronics Engineering Manager, Senior Account Buyer.

Table 8.1 Original action research plan (June 2002)

Phase	Objective(s)	Activities/methods to be employed	Expected Output	Dead line
I	• *Creating a common typology of suppliers that can be involved in product development* in order to determine the technological areas (parts) where Océ wants to increase supplier involvement in the next phase	• *Internal search and analysis* of existing supplier typologies and typologies related to supplier involvement • *Literature search and analysis* for supplier typologies and typologies	• Comparison of differences and problematic aspects	June 2003 -->Oct 2003
II	• *Determine the most important part categories* of current and future printer projects in which suppliers (potentially) play an important role during development.	• Pareto-analysis on relative value of most important part categories • Determine common development risks • Establishing the perceived contribution of the part in differen-tiating Océ products	• Overview of part categories sorted by monetary value and risks and contribution to printer functionality • Choosing part category for determining desired roles	Oct. 2003 --> Nov 2003
III	• *Determine the desired supplier roles and the associated requirements* for both Océ and the supplier regarding strategy, competences +organisation.	• Discussions with repre-sentatives of R&D, Manufacturing and Purchasing regarding the desired supplier role for the selected part categories	• Overview of relevant requirements for both Océ and the supplier regarding strategy, competencies and organisation for selected parts.	1 Nov 2002-1 Feb 2003
IV	• *Determine which suppliers can potentially fulfil* the desired supplier role in product development (current or new suppliers)	• Collect information on current/new suppliers • Organise evaluation discussions with representatives from R&D, Manufacturing and Purchasing	• conclusion of whether current supplier(s) meet requirements • conclusion regarding presence of conditions for collaborating according to desired supplier role	Feb 2003 - March 2003
V	• Incorporate insights into a tool and guidelines for preselecting suppliers in product development	• Collect information on current/new suppliers • Organise evaluation discussions with representatives from R&D, Manufacturing and Purchasing	• conclusion of whether current supplier(s) meet requirements • Conclusion regarding presence of conditions for collaborating according to desired supplier role	Feb 2003 - March 2003

In the remainder of this chapter we will particularly discuss phases 1,3 and 5, since insights during the research process led us to prioritise and reframe which ‘real issues’ to focus on.

8.4 Determining a commonly-accepted typology for supplier involvement in product development

We argued earlier on that in several of the eight case studies it appeared that the wrong supplier had been involved or the wrong type of involvement had been requested from the supplier. A common profile showing the range of potential supplier types and potential supplier roles that Océ could resort to would therefore seem to be a good starting point. We decided to collect further information about the existing typologies within the Océ organisation and compare these with supplier involvement typologies available outside Océ in other companies and in the literature.

8.4.1 Search and comparison of supplier involvement typology

We held a series of six exploratory interviews within Océ with managers and project members from the purchasing, manufacturing and R&D departments (see Appendix 8.2). They were asked directly about their personal and departmental use of typologies and terms referring to supplier involvement roles and supplier types belonging to these roles. We also consulted internal reports, procedures and strategy documentation, in addition to the literature and other publications on supplier involvement typologies and their logic. What we heard was, both for the Océ representatives and the action researcher, a surprising and overwhelming number of different terms and typologies. We found that a different typology was available or used pertaining to supplier involvement at seven different places within the Océ organisation. Table 8.2 reveals that, if we remove the overlapping terms, they have a total of 30 different terms.

Table 8.2 Overview of existing Océ typologies and terms related to supplier involvement

R&D Electronics Engineering	R&D Mechanical Engineering	R&D Sun project	Manu-facturing Approved Supplier List	Purcha-sing Strategy 1998	Purchasing Strategy 2001	Developmen t Portfolio procedure
System partner	Acquisition	Higher Leve System Buying	OEM	OEM	Strategic Partner	Category 1 parts (Strategic)
Development partner	OEM	Contract Assembly	System supplier	System Supplier	Higher Level System Buying	Category 2 parts (Leverage)
Resource partner	Development agency	Co-engineering	Specialist Black box	Module Supplier	Contract assembly	Category 3 parts (Bottleneck)
OEM/Strategic supplier	HLSB	ESI	Specialist White Box	Specialist	Supplier	Category 4 parts (Routine)
High level supplier	Single development Partner	Black box	Jobber	Jobber	Jobber	
Contract manufacturer	Engineering agency	White Box	Trader			
Jobbers/compone nt manufacturer	ESI plus supplier	(Red Box/ Grey Box)				
	ESI					
	Jobber					

We can explain the co-existence of such a variety of terms by the context of the specific departmental function and the design disciplines. The terms were developed or used by the departments and persons themselves, who each try to structure the problems they encounter in collaborations with suppliers during product development. Moreover, there does not appear to be a co-ordinating unit that aligns these different categorisations. In a similar vein, the literature review yielded a large variety of more than 14 different typologies and 61 indirectly overlapping terms (see Table 8.3). All these typologies make different assumptions about the suppliers and their role in development. We found at least five different types of logic underlying these typologies.

Table 8.3 Available typologies in the literature and in companies

Author	Typology/labels					Underlying logic and purpose
Kamath and Liker (1994)	Partner role	Mature role	Child role	Contractual role		Define supplier roles in product development between buyer-supplier relationships
Kaufman, Wood and Theyel (2000)	Commodity supplier	Colla-boration specialist	Problem solving supplier	Technology specialist		Focus on specific types of supplier and their typical area and capability profile
Sobrero and Roberts (2000)	Traditional sub contracting	Integrated sub-contracting	Advanced sub contracting	Black-box sub-contracting		Define different types of relationships in product development between buyer/supplier
Wynstra and Ten Patrick (2000)	Routine development	Arm's length develop-ment	Critical development	Strategic Develop-ment		Characterise individual project collaboration based on the extent of involvement and different levels of development risk
Laseter and Ramdas (2002)	Critical systems	Simple differen-tiators	Invisible sub-assemblies	Hidden components		Characterise different parts within a specific project
Clark 1989	Detail-controlled parts	Blackbox parts	Supplier proprietary parts	Off-the-shelf parts		Characterise the extent of supplier involvement for a specific part and the use of standard parts
Bidault et al.	Design supplied	Design shared	Design sourced			
Monczka (2000)	White-box	Grey-box	Blackbox	Off-the-shelf parts		Characterise the degrees of design freedom left to the supplier
Araujo et al. (1999)	Standardised interface	Specified interface	Translation interfaces	Interactive interfaces		Characterise different organisational relationships through the notion of how each company relates their internally controlled resources to those externally accessed through one of four resource interfaces
Bensaou (1999)	Captive Buyer	Market Exchange	Captive Supplier	Strategic Partnership		Characterise general buyer-supplier exchange relationships based on notions of dependence and risk
Olson and Ellram (1999)	Routine	Leverage	Bottleneck	Strategic		Characterise general buyer-supplier exchange relationships based on notions of dependence and risk
Bensaou and Venkatraman (1995)	Remote relationship	Electronic control	Electronic inter-dependence	Structural relationship	Mutual adjust-ment	Characterise buyer-supplier relation-ships in terms of a large set of variables determining the level of information processing needs and the capability to process information
Praat and Alders (1998)	Jobber	Process supplier	Application supplier	Main supplier		Typify the type of operations /activities and parts they deliver to their customers
DAF (Besuijen, 2003)	Make-to-DAF Specifi-cations	Develop-ment suppliers	Engineering suppliers	Technology suppliers		This supplier typology is coupled with the DAF performance level in develop-ing a particular part and the strategic importance of the part to DAF

We can detect some typologies that focus on classifyng different *types of suppliers* that could be used in product development. For example, compare 'strategic suppliers', 'Original Equipment Manufacturers', 'main suppliers', 'black box suppliers', 'system' and 'development partners'; these are viewed as companies that possess a set of integrated skills during the complete development and assembly trajectory. In contrast, 'Jobbers' and 'Contract Manufacturers' specialise in the production or assembly of parts. We noticed from interviews that many organisational members at Océ often speak directly in terms of these supplier types. These suppliers are all assumed to be good at different tasks and at providing specific expertise during different stages of product development. However, a clear profile and a coherent set of selection criteria are lacking.

Both within Océ and the literature, the part typologies are hiding assumptions about supplier contributions and capabilities for product development. During the four years of research we observed that the communication within and between departments also makes use of the quadrants of the adapted Kraljic portfolio code (Kraljic, 1983; Pothast, 1992) to characterise the type of supplier involved. These codes, which can be found in the last column of Table 8.2, include implicit assumptions about the type of contribution that they make to product development. Again, this typology does not help us to pinpoint what contributions these suppliers provide during different product development stages. Some portfolio typologies in literature (i.e. the contribution by Wynstra and Ten Pierick, 2000) go one step further and also link the type of communication to be adopted with a supplier in the development of a specific part.

Some of the terms also refer to the type of technical knowledge a supplier possesses for the development of a part. In other words, Océ views suppliers as having different experience and knowledge profiles for a certain function in their product. For example, 'Resource partners' are not considered to be specialised in a customer's specific application, but provide generic development or engineering expertise. In contrast 'System partners' and 'Development partners' are expected to have application knowledge linked to a customer base around a particular technology core.

A final logic underlying some of the typologies relates to the assembly level in the bill-of-materials or product architecture in which the parts are identified. Terms such as 'systems', 'functional units', 'modules', 'assemblies' and 'sub-assemblies' usually have a hierarchical order. A part supplied by a Higher Level System Buyer supplier or a System partner performs a recognisable function in the final product, whereas a 'Jobber' usually delivers components that are not visible to the final customer.

The consequences of having such a variety of terms and non-aligned categorisations became visible in the intensive discussions between Océ and its suppliers, and in their disappointment in each other's contributions. The non-alignment of these typologies with the Manufacturing and Purchasing organisation resulted in different expectations about these contributions. Effective communication between the members from the R&D, manufacturing and purchasing departments and the suppliers was inhibited by the use of terms that are based on different logics and foci. In the actual collaborations Océ's increasing involvement and control over the development, engineering and assembly activities suggest that additional 'repair' costs were made. At Océ the term 'Higher Level System Buying' (HLSB) has been the most visible example of how a specific term can stir up discussions at all levels in the organisation, and can create confused expectations regarding internal and supplier roles and contributions. The term HLSB was introduced by Purchasing in 1997 and officially referred to in the Purchasing Strategy document formulated in 1998. From interviews with representatives from Manufacturing, Purchasing and R&D, higher level systems were initially presented as complex and independently testable modules that matched a particular function in a copier/printer. Officially, high level refers to the added value that a supplier delivers to Océ in design and engineering; it does not necessarily characterise the number of components or the level in the product architecture at which the part is identified. A supplier of such an HLSB was expected to be responsible for the design, assembly and production or sourcing of the parts. However, such suppliers were not immediately found in or outside the current supply base. In the meantime, the manufacturing and purchasing departments introduced different practices to allow a different type of collaboration to emerge: parts were defined as if they were modules, but they did not coincide with the R&D decomposition or were largely designed internally. These parts were still referred to as HLSBs, which resulted in a change of meaning and different expectations both within the company and towards the suppliers.

8.4.2 Preliminary conclusions/ learning points

This analysis led the project team to further reflect on the impact of such a wide variety of terms on the ability to find the right suppliers. Among the cited studies in Table 8.3 and the interviews at Océ, there seems to be agreement on the need to distinguish between different types of buyer-supplier relationships in product development and in the mechanisms to manage these relationships. However, there seems to be no recognition of the impact of such a variety of terms within an organisation on the collaboration with suppliers. Having revealed this diversity and underlying logic, the project team and steering committee became increasingly aware of how difficult it has been in the past to develop efficient routines, across different departments and projects, with regards the selection of suppliers and determining the appropriate task division. This is because multiple interpretations and sets of expectations have been connected to single terms, while the typologies were not aligned internally or made explicit in the initial discussions.

Some explanations were put forward in the literature for the emergence of different terms, in this case related to 'supplier involvement in product development'. Brown and Eisenhardt (1995) refer to the contribution of Dougherty (1992), who demonstrates how product development projects are challenged to deal with the different 'thought worlds' that the various functional departments, to which the project team members belong, represent. Each department has its own 'fund of knowledge' i.e., what members know, and 'system of meaning'. i.e. how members know it (Dougherty, 1992). She argued that, not surprisingly, individuals from different departments understood different aspects of product development, and they understood these aspects in different ways. This difference led to varying interpretations, even of the same information. Interestingly enough, what distinguished successful projects was not the absence or presence of these barriers, but rather how they were overcome. For successful products, cross-functional personnel combined their perspectives in a highly interactive, iterative fashion (Dougherty, 1992). At Océ we can observe the same phenomenon of varying interpretations of the same information (read: 'supplier involvement typologies'). However, they were not always properly overcome, as we observed in the case studies.

We conclude that non-aligned typologies can become invisible barriers to effective supplier involvement and it is therefore necessary to develop a common terminology. The question is: *What terminology would allow the organisation to be more precise in defining the contributions of the supplier and the internal departments in collaborations during product development*?

8.4.3 Determining product development task clusters for the supplier and internal Océ actors: case study 1

We had a number of intensive discussions about what logic and what associated typology would be most clear and unambiguous. Although the discussions marked the starting point of an exchange of views and interpretations of these terms, it became clear that the abstract terms and/typologies inhibited a more concrete description of the underlying tasks to be performed by the supplier involved. The project team was not able to arrive at a detailed list of tasks that suppliers would perform.

We therefore decided to return to the actual practice at Océ, and to study four collaborations in which suppliers were involved, to different extents, in the development of a specific part. We identified the parts based on the team members' common knowledge about the presence of different supplier roles. These cases uncovered the tasks that were typically left to a supplier during different stages of the development. We also decided to record what tasks Océ would be responsible for, because discussions often focused primarily on what a supplier was expected to do and neglected Océ's contribution.

Table 8.4 Case studies to identify product development task clusters for supplier and internal Océ actors

Cases	Buy Part	Supplier
Case 1	Main frame assembly	Supplier A
Case 2	Magnet Roller	Supplier B
Case 3	Power supply	Supplier C
Case 4	Printed Board Assembly Image Processing	Supplier D

We developed a questionnaire that recorded the part development history during different product development phases in terms of the primary tasks carried out by R&D, Purchasing and Manufacturing project members and by the supplier. We specifically wanted to distil activities that the people themselves would indicate without influencing them by suggesting any terms and typologies beforehand. The project team would then analyse whether typical product development task clusters could be linked to an appropriate supplier type. After the representatives involved in the case studies had returned the questionnaires, a meeting was organised to verify what the activities actually meant. The results of the case studies were presented in the form of a comparative overview of the grouping of activities that representatives from Manufacturing Engineering, Purchasing and R&D considered the supplier to have been carrying out. The overview is presented in Table 8.5. As a check we also presented a second overview (Appendix 8.3) of the tasks each of the three representatives had been carrying out themselves. The task overview did not result in unambiguous, independent and meaningful task clusters. We observed the total range of tasks identified by the people. The clues that the project team derived from the case material was that suppliers play a role in developing specifications, building and testing prototypes, improving design in different aspects such as manufacturability, serviceability etc., and that they vary in terms of the assembly and production-related tasks. It was noted that the actors involved did not always provide a full picture of what happened during development.

We concluded that the bottom-up analysis approach did not yield the desired supplier involvement typology. However, the information from the case studies provided useful details that could be used at a later stage after an initial typology had been developed. One notable discussion that emerged in the group interviews concerned the question of whether supplier tasks would differ if they were involved in system development, module development or assembly development. In reality, the members disagreed about what systems, assemblies, modules and units really are in the context of Océ's products. Initially, the project team argued that if all members had the same perception of the decomposition of a final product, the supplier contribution could be more easily pinpointed. However, we also realised that these different perceptions (terminology) were too deeply rooted in the different departments and engineering disciplines to make it possible to develop a common typology within the available time frame. The new Vice-President of Purchasing chaired the project team meeting for the first time on 16 December 2002; he proposed radically changing the logic with which we had been working to develop a supplier involvement typology. This idea marked a change in the focus of our action research.

Table 8.5 Overview of supplier activities during different stages of the development project

Design step	Activities Supplier Mainframe	Activities Supplier PBA Image processing	Activities Supplier Engine Power Supply
Functional requirements initial functional set-up ready			
Towards Laboratory Model (LM)	**n/a**	**n/a**	Determine development costs of next phase
	n/a	**n/a**	Determine target price series and variance
	n/a	**n/a**	Build and delivery of prototypes
	n/a	**n/a**	First design
Lab Model ready			
Towards Engineering Prototype (EPT)	Lay-out design	Design for Manufacturability, Service etc.	Determine development costs next phase
	Quotation	Quotation made for prototypes	Determine prototype costs EPT
	Input regarding manufacturability (ESI)	Building and delivering first series prototypes evaluation	Make and send test reports
	Choose production tooling		Determine costs acquisition regulatory approvals
EPT ready			
Towards Reference EPT (REF-EPT)	Set-up production tooling	Draft analysis	Prototype costs EPT
	Building Prototypes	Build, delivery and evaluation of 2nd series prototypes	Test report
		Develop in-circuit tester	
	Tooling	Develop functional tester	
	Measuring (Testing)	Produce first parts for PVA machine	
	Part Quality Planning	Adaptation to first parts resulting from functional changes by Océ	
	Quotation	Engineering Prototype production	
	EPT production	Receive Quality-plan from supplier	
		Logistics-plan from supplier	
REF–EPT ready			
Towards first Production machines (PVA)	Part Quality Planning	**Development test equipment**	**Production and delivery of first parts for First Production Machines**
	Quotation	Build, delivery and evaluation of prototypes	
	Incorporating design changes	Produce first parts for First Production Machines	
	Transportation finishing tests		
	Set-up assembly line at supplier		
	Corrective actions		
PVA ready			
Towards regular production	Part put on regular contract	Part put on regular contract	

8.4.4 Degrees of design freedom in supplier involvement as a new point of departure

One of the initial eye-openers was the idea, suggested by the Vice-President of Purchasing, of starting from a situation in which a 'part' had to be developed, and to indicate the extent of design input that a supplier provides. A first line of thought pointed towards the variable degrees of design freedom that can be given to a supplier. In the past, Océ representatives appear to have used qualifications directly pertaining to a supplier type, such as, 'we need a jobber for the development of this sub-assembly' or 'we need a contract-manufacturer or HLSB-supplier'. The idea suggested was to avoid such references and discussions in the beginning. In addition, the idea was not to use detailed activity clusters as a starting point to define a supplier involvement typology. A set of three categories was initially presented along what would, in reality, be a continuous scale; from left to right it indicated an increasing extent of design input by the supplier. These main categories were: 'Detailed engineering', 'Construction' and 'Function development'. If the part were positioned in the 'Function development' category, then a black box development would take place based on functional specifications provided by Océ. It is important to note that the categories did not yet tell anything about the level in the product architecture in which the part was present. We conclude that the confusion in the Océ organisation was partially related to problems of calling different types of parts, referring to assemblies, modules and systems, as Higher-Level Systems, without being clear on the contribution they wanted from the suppliers.

The second idea was to distinguish between a 'part' and a 'module' in a situation where Océ asks for two different services from the supplier that apply to different boundaries of the total buy part. One service is the contribution to development and the second service is performing assembly operations that also involve other parts that have been specified by Océ. For example, in the case of the frame development of the copier, Océ changed the boundaries of the buy part by requesting design input for the core frame, but in the end wanted the supplier to deliver a more complex frame assembly with parts that were specified by Océ. What Océ failed to realise is that the frame assembly required a different method of collaboration and support during the engineering phases than the development of the core frame. In the light of the capabilities of the supplier, the requested contribution also had to be judged on two separate parts: the 'part' and the 'module' (i.e., the total assembly). By identifying these two levels of analysis, Océ could be more precise when determining in which areas of the buy part it expects the design contribution from the supplier. These two lines of thought are visualised in the following supplier involvement typology (Figure 8.1). Although the project team did not immediately embrace or fully understand the terminology or the logic behind it, we realised it was a breakthrough in thinking about supplier involvement. We therefore decided to continue working towards an initial design of a typology of supplier roles in product development. In contrast to some of the typologies found in the literature (Twigg, 2001; Wynstra and Ten Pierick, 2000) we had, for the time being, isolated the question of the primary supplier contributions to part design from the questions related to the type of suppliers and organisational mechanisms that are most effective to manage these different supplier roles. This focus was an important learning experience within the context of Océ; it will allow them to consider how they can make the contributions they require from the supplier more explicit.

Figure 8.1 Initial proposal supplier involvement typology

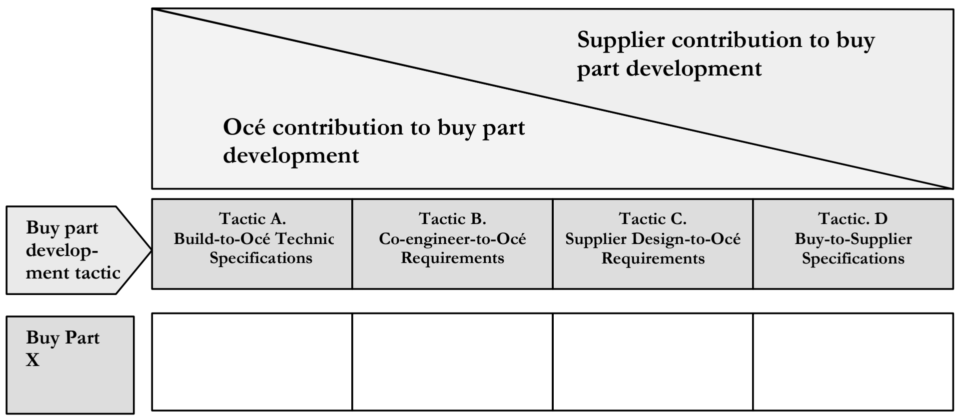
Supplier design input

	Detailed design	'Construction'	Function development
Part			
Module			

We returned to the literature to further develop a supplier involvement typology based on the primary design contribution. Many authors focused on the role of degrees of design freedom and of specifications in outsourcing of development activities (Nellore and Söderquist, 2000; Wynstra and Ten Pierick, 2000, Wasti and Liker, 1999). According to Nellore and Söderquist (2000) the broad definition of the specification process refers to the view of the specification document as an open arena for joint discussion and negotiation, and thereby also encompasses the process by which the document is realised. However, there are different choices possible on the degree of room provided to the supplier to complete the full specification. Nellore and Söderquist (2000) distinguish between two basic approaches that can govern the specification process and therefore imply different supplier contributions to the development of specifications: the 'commissioning' perspective and the 'mediating' perspective. The former relies on the execution of specifications by the supplier. The specifications are developed and communicated to the supplier in a one-way communication by the OEM. In the latter perspective, the specification is a 'forum for dialogue and thus created with a joint effort between different actors'. Another typology introduced by Bidault and Butler (1997) contrasts the sources of the design, in other words, whether it came from the buyer, the supplier or was a shared effort. This underlying logic was also a valuable perspective of characterising different supplier involvement categories. The last potentially useful typology considered was the supplier development responsibility dimension introduced by Wynstra and Ten Pierick, which distinguished between responsibilities based on 'functional specifications', 'global design, 'detailed design' and 'technical specifications'.

Our continued discussions helped us to develop an important insight, i.e., that the realisation of the specifications for a part was connected to the basic approach of how to combine different tasks and capabilities internally and externally. This insight had been to some extent been available. For example, Von Corswant (2002) discusses how buyer and supplier combine resources and link activities different activities together in product development). However, what mattered was the Océ context specific shift in thinking that was established. We considered this basic approach to be a specific '*development tactic*' and concluded that none of the previous scales could combine all insights in one term by which we could define the typology. After some brainstorming in the project team, we agreed on a typology that distinguishes between four main 'development tactics'.

Figure 8.2 Final supplier design contribution typology



It is important to emphasise that reality never completely fits with artificially drawn boundaries. We therefore considered adding a continuous scale to describe the increasing supplier contribution in design as a solid starting point. Moreover, the literature suggested the importance of defining the extent to which the specifications have matured in each category. We realised that a possible risk of confusion would exist if we used the term 'specifications' during all stages of the development process. In the early development phases, in particular, people tend to talk about a set of requirements that have to be translated into final technical specifications. We therefore considered introducing the term 'requirements', which was a known term but sometimes used in an inconsistent way. The first development tactic, *Development Tactic A,* was the first category that describes a development approach in which Océ designs the part and develops the initial technical specifications. Suppliers are primarily consulted about manufacturability aspects such as specified tolerances. The second tactic, *Development Tactic (B),* describes a joint effort regarding the design of a part for which a set of requirements has been formulated and Océ has developed the initial design concept. The third development tactic, *Development Tactic (C),* describes the development of a part in which the effort and input for the complete design comes from the suppliers based on a set of technical, regulatory and commercial requirements. The last development tactic, *Development Tactic (D),* describes the situation in which an off-the-shelf product or part already developed by a supplier, is chosen by Océ and is integrated in the final product. We expected these four approaches to cover most of the different collaborations in the Océ product development projects. We continued by creating a new plan to verify how recognisable the terms were in the broader organisation.

8.4.5 Testing and refining the supplier involvement typology: case studies series 2

We considered several methods of testing and refining the supplier involvement typology. First, we presented the framework in a cross-functional group of R&D and Mechanical engineering representatives, the Manufacturing Unit managers and the Supply Base manager. The initial feedback was that the terms only partially helped the representatives to distinguish between the supplier roles. A more detailed characterisation of the underlying responsibilities and contributions was desirable. Moreover, one of the Manufacturing Unit managers was specifically interested in the factors that determine the optimal choice for a specific development tactic. Although we considered the question of the conditions to be a valid one, we did not intend to prescribe the optimal development tactic in different situations at this stage of the research. Our main objective remained the creation of a typology covering most of the typical collaborations that Océ employed. We therefore decided to apply the new instrument in a large sample of cases. A senior buyer joined the project team at this stage of the research. His assignment was part of his professional development program to work on guidelines for improved supplier management for module sourcing. His objectives had a significant overlap with the objectives of the action research project and we felt that his involvement would therefore introduce fresh insights into our research process.

We had three main objectives in the second series of case studies. Firstly, we wanted to verify whether we could use our current instrument to quickly and easily discover the '*buy part development tactic*' chosen in other cases and any migration to other tactics during the collaboration. Secondly, we wanted to search for more detailed descriptions of the exact contributions of suppliers and explain any migration. Thirdly, we wanted to determine whether respondents easily relate to the way the instrument describes and defines different approaches to involve a supplier in product development. With regards the first objective, we asked the respondents to indicate their *initially chosen* and *end tactic* graphically, by positioning the parts in one of the four tactic boxes. We then asked what the underlying reasons were for any difference. Through a number of follow-up interviews we also gathered feedback on the clarity and support the distinction provides when trying to determine the supplier roles at the beginning and the end of the collaboration in a specific project. The individual results of the 25 parts are summarised in appendix 8.4. We also positioned the four case studies of section 8.4.4 in one of the four categories of this instrument.

We found that within the group of 25 different parts, three parts were based on development tactic D, i.e., a part bought according to supplier specifications. Nine parts were started following supplier-design-to Océ requirements (tactic C). Five parts were co-designed according to requirements provided by Océ (tactic B) and, finally, eight parts were completely designed by Océ (tactic A). Having examined the initial and end positions of the parts developed, we can draw a number of conclusions. First, we notice that in almost 50% of the 25 collaborations Océ ended up with the supplier contributing less to the design than was intended at the start. A close analysis of the type of parts reveals that the migration occurred particularly in parts containing multiple technologies and multiple design disciplines. Most shifts occurred in the intensive collaborations where Océ wanted the supplier to design to Océ requirements (five out of eight cases; development tactic C) or to co-design a collaboration (four out of five cases; development tactic B). Secondly, we observed that when Océ decided to buy a part according to supplier specifications, it tended to ask for the part to be customised. The customisation was necessary because the supplier specifications did not completely match Océ's geometric or functional requirements.

Analysing why Océ was not able to bring in the initial desired supplier contributions in these cases, we found that Océ spent little time beforehand on defining and verifying the precise supplier contribution and tasks to be performed in product development. The required capabilities were not always analysed upfront at the level of the different engineering disciplines and production technologies. Océ particularly underestimated the ability of the supplier to co-ordinate development activities with second tier suppliers in areas where it did not possess internal expertise. Moreover, we noticed that not all of the internal experts were involved on time to identify possible risks. However, we did learn that suppliers themselves did not pay enough attention to the feasibility of questions that Océ asked them. It appears to be very difficult to adopt a critical attitude towards a customer in a first or second collaboration.

We learnt that, in some cases, Océ had not created the technical design conditions necessary for the specific development tactics to succeed. When adopting a standard supplier part the interfaces and performance requirements must be defined in such a way that it does not require changes to the supplier design. In some of the cases, we noticed that they did not fully exploit the advantages of using existing designs. Moreover, if the interfaces are not stable and there is high interaction between the part and adjacent parts, it will be difficult for a supplier to keep track of changes and to start its production engineering work. If there is a high functional risk, optimising the design and making detailed drawings at mono-part level will always be partially in vain.

When a first tier supplier assembles a module that Océ has developed together with another, ultimately second tier, supplier, careful agreements on testing and quality control will be required for both suppliers. Certainly, introducing new production technology and acting as an intermediary between the first and second tier supplier has increased the risk of potential quality and co-ordination problems in the past.

Having done this test, it was important for us to find out what the value of the instrument was in its current state, including its application in real life cases for the Océ project team and steering committee. One of the reactions from the project team members was that the logic of the instrument and the visualisation had enabled them to discover the areas where Océ was not able to achieve the desired supplier contribution to the design of the part. An important property of the instrument was that it indicated subtle changes in initial and actual supplier contributions. Moreover, it provided valuable input for internal discussions and possibly discussions with suppliers as well. Although the members themselves knew that some collaborations had encountered difficulties along the way, the discussion could now be carried out with a common frame of reference using a simplified terminology.

One of the main remaining questions concerned the most important differentiators in each of the four categories. For example, the steering committee asked us to define more precisely the added value, the capabilities and the operational tasks that were typically left to the supplier in each of the development tactics. Other issues they wanted to know more about were which specific contractual agreements could or should be made, and what the organisation of the collaboration should look like when choosing a specific part development tactic. We therefore decided to address these questions in the final design of the supplier involvement typology.

8.5 Final design supplier involvement instrument/methodology

The idea was to identify the most important differentiators that help Océ to unambiguously define its supplier contributions. We also wanted to develop key areas of attention for actually setting up these collaborations. The attention areas contain the aspects that need to be considered beforehand for these contributions to be effectively brought into the development project. The cases and associated interviews led us to define five key areas of attention. We will briefly discuss what these areas are and how they can help us to the four development tactics. We will also demonstrate how these areas are strongly connected to a number of policy-setting and planning processes in the Strategic (SMP), Project (PMP)and Collaboration Management (CMP) arenas. Table 8.6 shows the five areas and their connections with the managerial processes.

Table 8.6 Connections between supplier involvement typology and managerial processes of IPDS framework

Supplier involvement key attention areas		'IPDS' Managerial processes
A.	Defining 'Needed development contributions' in terms of a basic buy part development tactic.	SMP 1 PMP 1 and 3
B.	Required dual capabilities and added value	SMP 4 PMP 2,3,4
C.	Requirements for preparing collaboration for buyer (OEM)	CMP 1,
D.	Organisation and management of operational collaboration	CMP 2,3
E.	Contractual governance	SMP 5 CMP 1

The first area to which companies should pay attention when developing a 'part' is thinking about the basic desired contributions from both parties to realise the part design. The outcome is a choice for a desired development tactic. A tactic is a basic approach to develop a part and is based on a specific task division between the buyer and supplier. In each tactic each of the parties provides a complementary set of design contributions. These contributions evolve (are connected) with a certain number of degrees of design freedom[2] that are left to the supplier. Focusing on supplier contributions does not imply that the evaluation of different types of suppliers should not occur. To clarify this, we grouped together in Table 8.7 a number of different types of suppliers that would typically be considered to provide this contribution. The emphasis on the specific tactic and primary contribution and the addition of the four typology terms enabled the people involved to use the terms more accurately. In other words, a discussion is less likely to get stranded in confusing 'term discussions' and without having defined what contributions are desired beforehand. Note that these four tactics encompass some of the different terms already used in the different departments. Table 8.7 outlines the key distinctions of each differentiating characteristic per development tactic.

Table 8.7 Key attention area A: Need a definition to choose the desired development tactic and associated desired supplier contribution in development

Characteristics	**Collaboration A** Full-Océ design-to-Océ requirements	**Collaboration B** Co-Engineer-to Océ requirements	**Collaboration C** Supplier Design-to-Océ requirements	**Collaboration D** Buy-to-Supplier specifications
Primary supplier contribution in part development	Production engineering (for mono parts supplier) Optimising design for assembly aspects	Product engineering (Production) Displaying design onto existing production technologies and based on Design for X (assembly, manufacturability)	Product development Customer-specific (function) development	Commercially available product Market specific application that has already been developed
Potential supplier types	Production/ Process/ Assembly supplier (jobber, contract manufacturer)	Manufacturing Engineering Partner Process Technology Partner (Contract manufacturer Resource partner; White box supplier)	Development partner (Black box supplier)	OEM /catalogue supplier

This first step can be to define supplier contributions for a specific development project, but can also aim at defining the key future contributions from suppliers for a specific technology or part category. This key attention area therefore aids the decision-making processes in the Strategic Management arena such as 'determining the in-outsourcing policy for technology and product development activities' and pre-selecting suppliers (SMP 1 and 4). It also supports the decision-making within the Project and Collaboration Management arena, such as in 'determining the project specific develop-or-buy solution', 'selecting suppliers', 'determining the extent of supplier involvement' and 'determining the work package jointly with the supplier' (PMP 1,3,4 and CMP1).

Having defined the development tactic and the desired primary supplier contribution, *the primary supplier capabilities and the typical added value of both parties* must be assessed. The main

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[2] Although the purchase part development tactic 'buy-to-supplier specifications' implies that the buyer no longer has any freedom (the supplier sells a finished product), we outline that the supplier still has the largest input in the development of the part. The customer's task is to assess whether the specifications match all the requirements it has defined one to one.

reason for distinguishing between the steps of defining supplier contributions and assessing supplier capabilities is to prevent discussions from immediately turning to specific suppliers and their general capabilities. The supplier capabilities must be assessed based on the specific technical and organisational requirements. For example, for a multi-technology part using a 'supplier-design to Océ requirements' tactic, the specific design capabilities in terms of mechanical and electronics design and its sourcing capabilities (e.g. early supplier involvement of second tier suppliers) may be critical. Analysing the part in terms of specific capabilities therefore provides an extra step to assess whether the collaboration stands a good chance of achieving its targets. For each desired contribution in the development of a part, we need a set of capabilities that provides added value. The main source of value in each tactic is therefore highlighted as well. This third area is connected to the supplier selection or pre-selection process (SMP4 and PMP2), and helps the company to define the selection criteria in the following step. Appendix 8.5a provides the key descriptions of the capabilities and primary added value.

Next, we argued that pursuing a specific development tactic requires the buyer to *prepare the collaboration* by providing the right maturity level of specifications and design for the part that corresponds with the degrees of design freedom of the chosen development tactic (see appendix 8.5b). We described both of these in terms of specifications and the maturity of the prototype provided to the supplier. This provides input to jointly determine the work package and target setting (CMP1). We have not detailed the target setting process in the table because we did not find enough distinctive ways or typical performance priorities of target setting per development tactic. More research is needed here. What does usually differ is the moment of supplier involvement. In general, the larger the supplier contribution, the earlier they are involved. However, within Océ we could not identify any unique moments that were typically attributed to each type of collaboration. We therefore note that the indicated moments are the most likely moments of initial contact with a supplier.

A fourth key area is the operational way in which the buyer and supplier will work with each other using an appropriate organisational interface (see appendix 8.5c). Both the cases and literature studied earlier (Araujo et al. 1999; Wynstra and Ten Pierick, 2000; Sobrero and Roberts, 2002) provided useful insights into the characteristics of the interface between the buyer and supplier in each of the four basic development tactics. This area is therefore connected to the process of designing the communication interface (CMP2). We have further detailed the following structural and collaboration process characteristics of the interface. In particular, we described the following for each of the tactics: the general organisational governance, the communication direction and content, the collaboration process in terms of desired behaviour and attitude, the typical composition of the buyer and supplier and the reporting format.

A final important area of attention is the conditions in the collaboration to be created from a contractual point of view. We therefore wanted to identify the mechanisms and relevant choices for each of the different development tactics. We identified around six elements that have to be considered in advance when setting up collaborations. These elements were discovered in the literature and during discussions in the steering committee and project team. First, the importance of characterising the different relevant contract types used in each collaboration situation was emphasised. These contracts include supply contracts, engineering contracts, development contracts and license contracts. In different collaborations the need to discuss and define precisely where the liability of each partner lies also becomes relevant and is governed by law. The cost aspects of quality problems have to be traced to one of the parties and the responsibility must be defined. A third important contractual, but also operational, decision regards the party who will create the technical documentation package and the party who will maintain it during regular production. Discussions typically also take place on the strategic and operational benefits and risks for deciding to outsource this task and responsibility. Furthermore, in more intensive collaborations, such as in collaboration B and C, intellectual property and design exclusivity become more relevant. It becomes a balancing act of creating economies of scale with the supplier and creating differentiation and quality advantages over the competition. See appendix 8.5d for a detailed overview of the six elements in each type of collaboration. Having developed the supplier involvement typology, we can now reflect on what new insights and knowledge this has yielded regarding the execution of pre-selecting suppliers.

8.6 Discussion

8.6.1 Reflection on the story in the light of the self-learning and the theory

We were originally aiming to improve the pre-selection process resulting in a methodology on how to define and find key suppliers to be involved in future designated technological areas. We learnt that a significant barrier was preventing Océ from moving forward in its thinking and managerial decision-making on the desired extent of supplier involvement. This barrier consisted of multiple sets of supplier involvement terms and typologies in the manufacturing, purchasing and R&D departments; these sets were not aligned and unknown to many of the project members. The action research at Océ pointed out that they needed a change in their routines and thinking about the desired role of suppliers in product development in order to improve the performance in collaborations with suppliers. Further research in the literature strengthened our observation that a variety of terms exist based on different underlying logic. The underlying logic is valuable, but have to be carefully understood how the author perceives and defines supplier involvement. As a researcher, I observed just how difficult it was to discuss and determine what each term really meant. The co-existence and misalignment between the typologies in different departments revealed the need to develop a supplier involvement typology that allows the organisation to reflect, discuss and communicate about desired supplier contributions in the development of parts. It was therefore not a matter of determining that typologies were 'wrong', but of finding a connection with the frames of reference of the project team members and, preferably, in the whole organisation.

The output of the action research is a supplier involvement typology presenting four different types of supplier contributions in product development. From the buyer point of view, the typology departs from the logic that a specific 'development tactic' needs to be chosen for each part that articulates the nature of the design input in relation to the specification maturity. This means that the terms directly communicate the balance of the design effort and the degrees of freedom that are still available for the supplier's design contribution. We distinguish between four basic 'tactics' to develop a specific part with different supplier design contributions.

Development tactic A *'Full-buyer- design-to-buyer requirements'*

Development tactic B *'Co-engineer-to-buyer requirements'*

Development tactic C *'Supplier-design to buyer requirements'*

Development tactic D *'Buy-to-supplier specifications'*

In terms of guidelines for using this typology, we defined five key attention areas supported by tables that can be linked to a number of managerial processes of the IPDS framework. Before actually involving suppliers, a company should start by: (A) defining the needed development contribution and continue with four additional steps to indicate (B) what typical supplier capabilities need to be found for a supplier to deliver the desired contribution, (C) to define what preparations a buyer must make before the collaboration starts, and to indicate (D) the appropriate operational and (E) contractual governance mechanisms per collaboration type. Our conclusion is that if people cannot explain and execute joint or informed decision-making regarding the expected contributions from internal departments and external suppliers, the actual development activities in the collaboration will start off on the wrong foot, resulting in misunderstandings and creating technical problems and increased governance costs. Development projects will be less efficient and will inhibit managers and project members from spending valuable time on other activities.

One of the most challenging tasks for companies when involving suppliers is to manage different sorts of risk, especially those risks that have an impact on the collaboration with suppliers. Océ representatives strongly questioned the extent to which particular risks can be anticipated and the extent to which these risks have led to problems in collaborations with new suppliers or new collaboration areas. We do not contend that all risks can be foreseen or avoided. However, developing a more explicit and systematic process through which different needs (i.e., the specific capabilities and tasks that are required to develop a part of a final product) are put on the table, discussed and assessed, would help companies to detect risks before they occur and help them to address them. This process requires the timely involvement of 'operational experts' from different departments to assess the risks, and of boundary spanning actors (R&D/Manufacturing and Purchasing) to create 'strategic' management commitments. This supplier involvement typology can be an important facilitating reference point that can be used to identify a number of potential risks and to create meaningful cross-functional decision-making regarding supplier selection.

We also learnt that it is important for the buying company to make clear how much they are going to take part in the preparation, so that the supplier can provide his agreed contribution. These preparations are of a technical and commercial nature, such as providing the right level of maturity of design information, defining clear and stable interfaces for the part with the rest of the machine, and giving realistic and clear targets. If the internal buying organisation is not clear about the specific contribution it wants from its supplier, the buying organisation is not creating the conditions for the supplier's expertise to be integrated in the project. For example, if you ask a supplier to develop a functional module but provide prototypes and detailed drawings, this limits the room to provide the knowledge and to improve the part concept. If such mismatches are persistent, project teams will be confronted with sub-optimal designs and misunderstandings. The buying organisation may not be able to really free up its internal R&D members for more critical and differentiating technologies and functions. If used in this way, the supplier involvement does not help to speed up or increase the product development productivity and innovativeness (Gadde and Snehota, 2000).

By engaging in action research to create and study organisational change, we have added to both the theoretical and practical knowledge on managing supplier involvement. The analytical tool and guidelines help a company's internal departments to engage in effective discussions on when, and to what extent, to involve suppliers. The tool can therefore be supportive in the pre-selection discussions on a long-term strategic level, and within the decision-making contexts of a development project and individual collaborations. Rather than developing an overall truth, the action research points to the importance of at least creating a shared terminology that can be used internally and externally in order to make strategic and operational choices about the use of different types of supplier capabilities in the development of parts. Therefore, this framework, which defines the different contributions of the supplier, is not meant to be a universally applicable terminology. What is most important is that it has been developed by internal and external confrontations and comparisons with the literature through a process of organisational learning. One important benchmark was the moment that some of the team members started to explain to their colleagues what they really expected from different types of collaborations and suppliers. It is this exchange of views that is supported by the instrument. We emphasise that the application of the decision-making support instrument is both useful at the managerial level and in product development teams.

We have also developed new insights into the process of instrument development itself. Although it appears that a number of initial efforts did not lead to significant results, in hindsight the barriers provided us with clues to a different possible approach. The initial issue framing and planning were subject to revisions that were unforeseen in the initial plan. According to Coughlan and Coghlan (2002) the action research consists of the cycles of planning, taking action and evaluating; these are anticipated but not planned in detail in advance. The exact unfolding of events had therefore not been planned or foreseen. However, they argue this is not necessarily a problem as long as '*...the data explorations demonstrate a high degree of method and orderliness in reflecting about and holding onto the emerging research content of each* *episode and the process whereby issues are planned and implemented'* (Coughlan and Coghlan, 2002; p. 229). At Océ we ensured that the initial planning was followed up by regular meetings with minutes, agendas and reflexive phases. Being an action researcher means struggling between exploring and trying, as one would do in a labyrinth. However, an action researcher does not go into a maze unprepared, and knows there is only one-way out. The way out is a synonym for a solved issue. Sometimes the solution involves creating a search and communication experience without actually executing it. It has exactly been this shared experience, in combination with providing clarifying ways of approaching an issue without actually making particular decisions regarding technologies and suppliers! Although this would be desirable, we realised that the conditions were not yet present to make it feasible.

8.6.2 Extrapolation to a broader context and articulation of usable knowledge

Action research is explicitly concerned with theory that is formed from the conceptualisation of the particular experience in ways that are intended to be meaningful to others. Theory building as a result of action research will be incremental, moving from the particular to the general in small steps (Coughlan and Coghlan, 2001; 2002). If we define the contribution of the research in the context of the broader body of scientific knowledge, we can state that our contribution to theory is related to adding knowledge about organisational change in the context of collaborating with suppliers in product development. Improving processes related to supplier involvement hinges on an organisation's ability to jointly reflect on a focused topic.

8.7 Conclusions

In this chapter, we aimed to use the diagnosis results of two series of empirical case studies at Océ and the four other companies (HJH, DAP, PAN and BE), to further improve a key strategic process at Océ, namely the pre-selection of suppliers for involvement in future development projects. We can now state that we developed specific insights and knowledge into the implementation of the management of supplier involvement.

We started by using the knowledge generated from applying the analytical framework for IPDS to further detail how companies are hindered in managing supplier involvement on the short and long-term. One of the major bottlenecks in selecting or pre-selecting suppliers for involvement in product development is the failure to define and agree explicitly on what contributions are expected from the supplier. The action research revealed that one of the barriers is the co-existence and non-alignment of a large variety of terms among internal departments and its members, making different assumptions about supplier's contributions, capabilities and tasks to be performed in product development. These differences are not made sufficiently explicit when members of the manufacturing, purchasing and R&D departments are involved in setting-up different collaborations with suppliers. We therefore argued that organisations should develop a shared terminology across different departments before entering collaborations with suppliers in new or different technologies or parts.

A second condition for effectively pre-selecting suppliers is related to the initial determination of how an organisation would like to develop the part based on different buyer and supplier contributions to its development, instead of immediately fixing desired supplier types or choosing 'appropriate' suppliers. This appeared to be one of the pitfalls that the Océ organisation fell into in the past. The output of the action research is an instrument that starts by determining the exact 'need' or desired supplier contribution. We distinguish between four basic 'tactics' to develop a specific part based on four basic configurations of supplier contributions to product development. The contributions are defined along a continuum from 'Full-Océ-design-to-Océ requirements' to 'Océ buys to supplier specifications'. The instrument further describes four additional key attention areas referring to the type of typical supplier capabilities needed for a supplier to deliver the desired contribution, to define what preparations a buyer must make before the collaboration starts, and to indicate the appropriate operational and contractual governance mechanisms per collaboration type.

Besides using the instrument in strategic discussions for pre-selecting suppliers, it can also be helpful as a means of initially defining the desired supplier contributions and the collaboration type within development projects. The instrument therefore supports the following specific managerial processes of the IPDS framework: 'supplier selection process', 'determining the extent of supplier involvement', 'determining of the work package and contract' and 'designing the communication interface'. The earlier the instrument is used in a development project, the broader the range of options regarding supplier contributions to choose from, and the easier it will be to detect potential mismatches between the available supplier capabilities and the desired contributions.

We have also noticed that if a higher transparency in terminology is used across the different organisational levels, this could contribute to the organisational members being more committed to collaborations with suppliers. In the end we did not develop a blue print for the actual selection of suppliers for specific technological areas, but focused on the creation of an instrument to help create a shared terminology for determining supplier contributions in product development. During the action research project we learnt about the importance of, and means for, dismantling invisible communication barriers. Creating a shared vision about the technological areas where suppliers should be involved in product development, and building the supply base by pre-selecting such suppliers, cannot effectively start unless departments are able to define and explain to each other what they expect from suppliers. If collaborations are systematically able to define and fine-tune their contributions in the development process, the precious time gained can be invested in processes such as identifying future opportunities with suppliers.

In the next chapter we integrate the findings from this chapter with the insights developed in previous chapters and present their overall contribution to managers and the body of knowledge on managing supplier involvement in product development.

Chapter 9
Discussion, conclusions and recommendations

9.1 Introduction

In this dissertation we empirically examined how companies can effectively manage the involvement of suppliers in product development. What we revealed was the complex reality of managing collaborations in the area of product development. Our primary research objectives have been:

- to empirically examine the critical managerial activities and conditions for effectively using the leverage of suppliers' resources to help improving short and long-term product development performance;
- to develop an analytical framework that can be used as a reference for diagnosing and improving the management of supplier involvement.

In this final chapter, we summarise the research process and findings of our study in section 9.2, and present the conclusions in terms of our answers to the research questions in section 9.3. We continue with a discussion on the contributions to existing literature in section 9.4 and a discussion of the implications for practitioners in section 9.5. In section 9.6 we discuss the limitations of the research, finishing the chapter in section 9.7 by providing suggestions for future research.

9.2 Summary

This study was based on the premise that the actual results of supplier involvement in product development as reported in previous studies have been mixed and suggest a more deeper understanding to the organisational and managerial aspects of this phenomenon is necessary. Companies in different industries appear to have become aware of the potential benefits, but may have insufficient knowledge about how to manage their involvement. We therefore considered further investigation to be warranted into the underlying causes in terms of the critical managerial practices and conditions in which companies initiate collaborations with suppliers in product development. Following a broad overview of the trends and drivers in supplier involvement (see Chapter 1) and an extensive literature review (see Chapter 2), we developed the following research questions:

1. *What short- and long-term objectives may underlie a company's intention to involve suppliers in product development?*
2. *What management processes are critical for achieving the short and long-term objectives of supplier involvement?*

3. *What factors actually support the execution of processes aimed at managing supplier involvement in product development?*
4. *What contextual factors increase the need for executing the processes aimed at managing supplier involvement in product development?*
5. *How can an analytical framework be used as a reference model for diagnosing and improving the processes and conditions underlying the effective management of supplier involvement?*

In the initial literature review we provided an overview of existing literature in terms of five clusters; we then compared their perspectives, models and approaches in studying supplier involvement in product development. We specifically highlighted previous work by Wynstra (1998), Monczka etal. (2000) and Takeishi (2001). They take a broader perspective on the internal and inter-organisational management of supplier involvement compared to the dominant relationship, project and actor perspectives studied by other researchers. We argue a broader perspective yields a more comprehensive understanding of a complex phenomenon.

We next selected an existing contingency-based analytical framework (see Chapter 3). The 'Integrated framework for purchasing involvement' (Wynstra et al., 1999) groups a set of managerial activities into four managerial areas that contribute to five underlying processes. It also identifies the enabling conditions that support the effective management of supplier involvement and the contextual conditions that drive the need and form of these activities. After reviewing additional literature, we made some adaptations before starting the empirical study to further investigate the conditions, managerial activities and results of supplier involvement in real-life case studies. The review resulted in the identification and addition of two groups of short and long–term objectives of supplier involvement. We also found additional relevant enabling and driving conditions, which were grouped at three different levels of analysis. This resulted in the first revision of the originally selected framework. The framework was given the name 'Integrated Product Development and Sourcing' (IPDS) in order to emphasise the need to integrate product development with sourcing processes. This reduces the focus on the role of purchasing in managing supplier involvement.

To answer the five research questions we decided to choose for a combined use of different qualitative research methods. This allowed us to study the complex and dynamic nature of the phenomenon. We were able to further validate the framework using a spiralling process between theoretical reflection and empirical observations at various stages of the research. We started a series of eight different embedded, longitudinal case studies of collaborations at Océ[30] to examine the way this company manages involvement of suppliers in product development (see Chapter 4). We developed a historical account of the collaboration and subsequently distilled issues and problems encountered by Océ.

[30] A Dutch company specialised in developing and manufacturing professional printers, and providing document management services.

We continued to analyse the case studies using the analytical IPDS framework (see Chapter 5). This analysis revealed that the high and low performing collaborations and the associated issues and problems could largely be explained by the persistent patterns in the extent to which Océ planned and set-up supplier involvement. We found that our initial revised framework was very helpful in understanding why certain collaborations were not effectively managed. However, the framework was not complete in terms of the relevant activities and conditions. Moreover, the analytical distinction of four management areas did not sufficiently reflect empirical reality.

These insights resulted in a reconceptualisation and further detailing of the IPDS framework (see Chapter 6). Instead of four managerial areas, we distinguished between the '*Strategic Management Arena*' and the '*Operational Project Management Arena*', where an 'arena' is defined as a sphere of activities (Oxford Thesaurus, 2001). The Strategic Management arena contains seven processes that together provide long-term, strategic direction and operational support for project teams adopting supplier involvement. These processes also contribute to building up a *willing* and *capable* supply base to meet the current and changing future technology and capability needs. The Operational Project Management arena contains nine processes that are aimed at planning, managing and evaluating the actual collaborations in terms of their intermediate and final development performance in a development project. The two arenas are both distinct and interrelated, as the interplay between short-term project interests and long-term strategic interests are managed in these arenas. In terms of the conditions for supplier involvement, we added and regrouped a number of enabling and driving factors. We learnt that these conditions had to be analysed and verified at different levels in the organisation: at the level of the collaboration itself, of the project team and of the business unit or company.

We next compared our newly-developed insights with other companies such as HJ Heinz, PANalytical, Philips Domestic Appliances (DAP) and Boon Edam, by examining eight development projects with an average of two supplier collaborations in each project. In this way we applied the revised framework in a wider variety of contexts (see Chapter 7) and examined its robustness. The cross-sectional case studies were also used to further develop the framework as a diagnosis instrument. On the whole, the framework appeared to be able to give an integrated view of possible reasons why certain collaborations did not meet their targets. Its function as a useful diagnostic instrument for companies was also largely confirmed. Successful collaborations were supported by a visible cross-functional organisation and collaboration. Moreover, companies developed a pre-qualified supplier base and balanced short-term project demands with strategic issues for future projects in the collaboration with suppliers. The evaluation of development performance and processes appeared to be a key factor in learning from collaborations and internal decision-making. The cross-sectional case studies allowed us to define three important managerial arenas that consist of the management of supplier involvement at the collaboration, project and strategic levels. We also distinguished between the co-ordination and evaluation processes at the project and collaboration levels.

Having empirically examined the management of supplier involvement we decided to conduct a final empirical study to develop guidelines for improving one of the critical processes that emerged from the previous two series of case studies (see Chapter 8). We found the process of pre-selecting suppliers for involvement in product development in designated technological areas to be one of the key processes underlying their effective involvement. Successful collaborations were characterised by the presence of pre-qualified suppliers with a clear awareness of the possibilities and limitations of their capabilities. This insight provided a further trigger to set up our last piece of empirical research to develop guidelines for improving this process. During the action research project at Océ we worked closely with Océ representatives and often referred to the existing literature; this enabled us to gain additional knowledge and to develop a practical instrument. The knowledge pertained to why and how companies need to develop an internal understanding of, and the ability to communicate, the contributions it desires from suppliers in product development. Developing a terminology that is shared among representatives across different departments is an important condition for developing an aligned and realistic strategy on the contributions of suppliers to be pursued in designated technological areas.

Our analytical and empirical work resulted in two main outcomes. The first outcome of this thesis is a new in-depth knowledge and an integrated view on the critical conditions and processes for effectively managing supplier involvement in product development. This integrated view is provided by an analytical framework that was developed by improving an existing model (Wynstra, 1998) through empirical and theoretical reflection. This reflection resulted in comparing and adding relevant concepts and aspects of managing supplier involvement proposed in the literature. Moreover, the insights have been anchored in the more generally available theories in strategic management, organisation and product development areas. The second outcome of this thesis is an empirically-tested diagnostic instrument that allows strengths and weaknesses in the decision-making and collaboration between internal departments (purchasing and R&D), but also between the company and the supplier, to be detected. This computer-aided instrument provides a means for analysing and improving managerial processes and conditions by pointing to the specific management arenas (strategic, project and collaboration) in which the weaknesses have been observed. The contribution of this thesis is not limited to providing new insights to the theory on supplier involvement, but also presents a useful instrument to help R&D and Purchasing managers to shape and implement an effective supplier involvement strategy.
These outcomes are explained in more detail in the next section where the findings of this work are discussed by answering the five research questions.

9.3 Findings and discussion

1. *What short and long-term objectives may underlie a company's intention to involve suppliers in product development?*

We arrived at this research question as few previous studies had gone beyond the identification and measurement of the performance of specific collaborations in a particular development project. Since the initial framework developed by Wynstra (1998) did not explicitly measure the results of supplier involvement, we introduced additional variables before empirically examining cases of supplier involvement in product development. We made a distinction between the short-term objectives set for the development of a specific part in collaboration with a supplier, and the long-term objectives a company can pursue when working with a supplier in product development. This distinction was based on benefits discussed and proposed in a few previous studies on supplier involvement. Employing the short and long-term measures, in practice, at Océ, DAP, PANalytical, Boon Edam and HJ Heinz yielded an interesting but mixed picture.

Findings short-term collaboration objectives

We will start by discussing the appropriateness of using the performance dimensions identified in previous academic literature. We introduced four major collaboration objectives that are important in the development of a part: *technical performance, cost, development time and development costs*. We found that these dimensions were relevant for most companies. However, the exact operational measures for the four performance objectives are hard to compare across companies and in different industries. If we consider the *technical performance* dimension, one company did not consider this to be an applicable dimension because it was accustomed to different underlying measures. For example, relevant measures underlying technical performance in series production industries, such as 'functional performance', 'field reliability', 'durability' and 'corrective maintenance rates' are not applicable in the food industry. Companies in the food industry are particularly concerned with quality measures regarding the taste, colour, preservation aspects of the ingredients and the packaging. The second collaboration objective, i.e. lower part costs, is also subject to different interpretations in terms of its measurement. At Océ we found that, when assessing or setting targets in the early stages of a development project, R&D and Purchasing had traditionally not taken the same relevant elements into account with regards cost price estimates and underlying models. The contract price was different from the initial R&D assessment, because R&D did not assess logistics costs, overheads and supplier profit margins. The buyer needed to asses these elements separately. Although Océ did discuss differences and fix a target price during the project, their practice was different from other companies. We chose to measure the initial part cost target and the final contract price for the part. In terms of achieving benefits regarding *development costs*, we found that most companies were likely to have finished with higher *development costs* than expected. However, companies often only took into account part of the total costs associated with developing a part with a supplier. Whereas the number of engineering hours and costs for prototypes are relevant costs, they were not always monitored. Moreover, additional hours spent by internal engineers on co-ordinating or 'repairing' were not always included in the development costs or traced to particular collaborations. For example, typical differences between companies in the food industry and other companies are related to the tooling costs that are sometimes made when developing parts. Some companies include them in the part cost price, whereas others consider them to be development costs. Finally, we confirmed that the *development time* needed to release a part for production was indeed a relevant objective. We found that distinguishing between the adherence to intermediate prototype planning and examining the actual impact on delaying project planning can provide a balanced picture of the benefits or damage resulting from a specific collaboration. What was striking was that the collaborations neither delayed nor sped up the project, but that the development planning could benefit from delays (elsewhere in the project). Océ sometimes allocated extra internal resources to the collaboration to make up for intermediate delays.

We have considered various ways of measuring the performance of collaborations with suppliers in a development project. For example, we can use 'objective' data from the field and compare it with the actual-to-target performance, or we can use external benchmarks such as comparing the internal performance with the performance of competitors or of companies in other industries that use similar parts. Internal benchmarks can also be used, such as comparing the cost performance to past performance for a similar part. The possibilities for using such measures depend largely on the data that companies use themselves to track performance, and in their way of setting targets. We conclude that the specific objective targets and actual outcomes are not always both available. In other words, the next best alternative is to measure perceptions in terms of actual-to-target performance. We therefore found that a good compromise to quickly determine whether a collaboration has performed well is to use a perceptual 'actual-to-target measure' for the four performance objectives and to ask the most well-informed people to provide the judgement. One of the remaining problems is the difficulty in determining how realistic the objectives are.

We can conclude that including the short-term performance objectives in our framework was both relevant and helpful in setting a reference point against which a number of problems and issues can be understood. We argue that these case studies are in line with the mixed findings in studies by Ragatz (2002), Primo and Amundson (2002) and Zirger and Hartley (1997). We have observed that supplier involvement can contribute to improving quality aspects of the final product. It is important to distinguish between functional performance, reliability, durability and aesthetic performance. Failing to achieve one of these quality aspects can cause significant in-project costs and correction costs when the final products are in the field. Besides assessing the short-term collaboration results, some of these collaborations may have yielded additional long-term collaboration benefits for the companies involved, thus increasing the potential value of involving suppliers in product development.

Findings long-term collaboration objectives
We found that potential long-term collaboration benefits derived from a particular collaboration experience were not always consciously considered by the project team representatives involved in the collaboration, or monitored by the managers from the various departments.

The most dominant long-term benefit to occur is achieving *improved efficiency and effectiveness of future collaborations as a result of learning experiences from the current collaboration.* In other words, organisations that have learnt to understand each other's ways of working, technical requirements and supplier's capabilities will be faster and will improve the quality and cost of their designs by making timelier, relevant suggestions. Such benefits partially compensate the negative results obtained within an on-going collaboration. We found that it is critical for companies to value such benefits if they are to maintain a long-term focus when deciding to increase supplier involvement. Sobrero and Roberts (2001; 509) underline this, '*...the recognition of the potential benefits of external relationships to strengthen the internal resource base should not overemphasize associated costs*'. How difficult this is in practice became apparent at Océ. Its initial intention to consider one collaboration as a test for which 'learning money' could be paid became under pressure when higher development costs were reported and no direct follow-up projects were initiated.

Moreover, learning experiences can also result in a more visible benefit by applying solutions developed in one project to other projects. We did not encounter many cases of this, but some informal learning about dos and don'ts did occur at Océ. At a micro level, components can be reused thereby resulting in standardisation benefits. At a technology level, a technology platform policy can be defined, thus allowing the implementation of externally-driven technology improvements to be better synchronised across multiple products and projects. This could reduce the co-ordination and operational workload. Another mechanism of passing on benefits is the use of task groups with suppliers. If they successfully use the informal and formal communication channels, this will allow different projects to benefit from the learning experiences in other projects. We found that such experiences occurred in collaborations with medium-to-highly complex or innovative parts. However, we did not observe the impact of such arrangements on truly developing parts faster, with fewer resources, or on achieving greater design quality and lower part costs. In intensive collaborations in new technological areas, the benefits of the *alignment of technology roadmaps* were perceived as being most relevant and occurred most often at HJH, DAP, PAN and Océ. The *improvement of access to the supplier's knowledge base* was related to the willingness of a supplier to share specific technical know-how, and to the availability of technological solutions and knowledge for future use as a result of motivating actions in the past on behalf of the buyer. Although we were able to establish that this long-term benefit was partially captured by Océ, in the other companies we had to depend on the perceived availability by representatives from the purchasing and development departments.

We conclude that collaborations that fail to meet short-term targets can apparently create potential benefits allowing a company to engage in more efficient collaborations and to develop improved design through learning experiences in the future. Furthermore, an improved willingness of the supplier to grant access to its knowledge base will allow a buying company to benefit from their innovative solutions. Finally, the timely availability of such supplier products and specific knowledge can be achieved through creating a better-aligned technology roadmap. Such long-term benefits however are rarely set as a conscious objective. We found particular evidence that companies who only focus on meeting development targets for a part, underestimate the positive change in value of the total relationship through this particular collaboration experience. Moreover, the identification of potential long-term benefits is no guarantee of capturing them. These observations made it even more relevant to investigate the underlying managerial processes and conditions that allow companies to exploit such benefits in future projects while ensuring the achievement of short-term development objectives.

2. *What management processes are critical for achieving the short- and long-term objectives of supplier involvement?*

We answered this research question by examining managerial decision-making and actions in a single high-tech company and in four additional company contexts. We based our research on an existing analytical framework selected from the literature (Wynstra 1998).

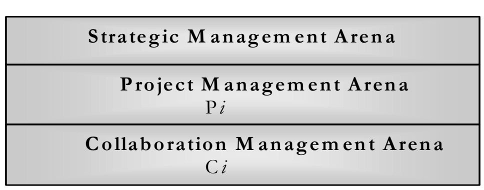
The mixed results in the operational collaboration with suppliers at Océ can be partially explained by the way the manufacturer set up the collaborations and co-ordinate development activities with the first and second tier suppliers in development projects. Specifically, we found that technical and organisational problems pointed to an insufficient match in the contributions Océ expected from the supplier and the available supplier capabilities. Consequently, collaborations required a disproportionate amount of co-ordination effort between Océ and the first tier suppliers. The critical processes that underlie these problems were related to the way it defined the desired collaboration area by decomposing the final product into appropriate buy parts, and the way and extent to which management and project team members systematically considered and integrated relevant criteria in advance. Consequently, the supplier selection process in a development project did not always result in committed supplier choices and resulted in ongoing discussions and doubts during and after the project. More specifically, Océ did not spend enough time, and was not explicit enough, on determining and discussing the appropriate extent of supplier involvement. In addition to these decision-making processes, we connected the problems to the extent and way in which buyers were setting development targets (quality targets, intermediate prototype planning, cost price targets and models) and fine-tuning work-packages and specific deliverables with their suppliers. These activities were also emphasised in the work by Monczka (2000). This appeared to be even more important when the project started working with new suppliers or introduced new technologies or design concepts and supplier product/component life cycles were short. We also found that designing and fine-tuning the right communication structure with both the first tier and the second tier suppliers were critical activities in such situations.

Additional explanations were found in the extent and way in which Océ managed supplier involvement at a strategic level. It did not have a clear, consistent and comprehensive approach to pre-qualifying suppliers for involvement in product development. In particular, its pre-selection approach during the period of the case studies did not support its intention to increase the involvement of suppliers in development and assembly for several new multi-technology parts. Pre-selection appeared to be a key step in transforming the current supplier base towards one with different capabilities that add more value to the future product development performance. Moreover, Océ did not have clear supplier involvement guidelines for setting up and managing new collaborations, which resulted in extra effort and misunderstandings. The collaboration with suppliers was particularly hindered by the existence of a diverse set of terms in the various departments, with implicit assumptions and expectations about the role of suppliers in product development. Finally, Océ did not immediately create the conditions to benefit from existing supplier products and designs. In other words, Océ resorted to adaptations to supplier-generated specifications or designs, which undermined the speed and resource advantages in developing the part and managing the logistics, manufacturing and service for these parts. The case studies exhibited more extensive co-ordination efforts by the purchasing, manufacturing, logistics, R&D and service departments during product development and regular production than was expected. Renewing the supplier base, to achieve a higher added value of the supplier in product development and assembly, was a process full of obstacles and involving a great deal of trial and error.

In the second series of cross-sectional case studies at Heinz, DAP, PANalytical and Boon Edam, we found that companies with the most successful projects and collaborations (in particular at Heinz and DAP) had built and managed a carefully selected supplier base with relevant capabilities for specific commodities/technological areas. They accessed these capabilities in a specific development project by pro-actively and systematically identifying the desired types of collaborations, and by systematically setting up individual collaborations in which the expected contribution and targets were agreed upon and fine-tuned jointly with the supplier. Heinz ensured that long-term collaboration benefits were captured by an explicit series of connected evaluation processes. These evaluation processes were about the development performance of individual suppliers after a specific collaboration, but also analysed the performance of multiple collaborations and their impact on the overall project performance. Finally, evaluation discussions took place at a strategic level to review the supplier base in the light of future product planning and required technologies. In other words, such companies were equally active in strategically and operationally managing supplier involvement. They established an iterative cycle of decision-making, execution, evaluation and adjustment, using multiple, relevant management arenas that allow short and long-term interests to be considered.

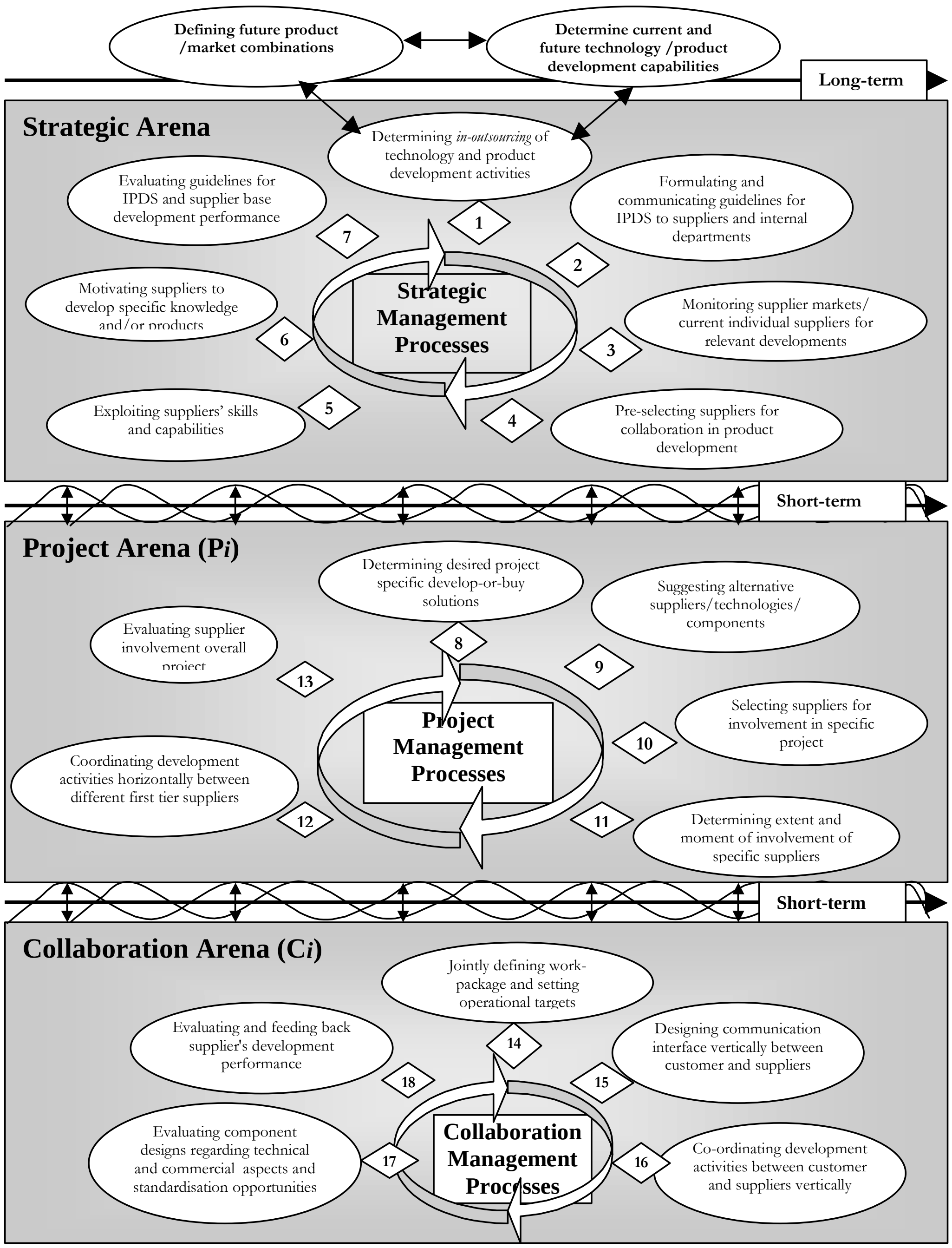
These findings resulted in a number of adaptations to the framework for analysing the management of supplier involvement. First, in terms of the relevant managerial areas, we learnt that by identifying a *Collaboration*, *Project* and *Strategic* management arena where supplier involvement is managed, management practices could be better captured than when using the four management areas identified by Wynstra (1999). There are a number of reasons for this. The first reason is that companies need to pay attention to managing individual collaborations. We argue that adopting a 'relationship view' is actually 'black-boxing' a phenomenon that itself is driven by events and different collaboration episodes that together drive an evolving relationship. The case studies carried out with the four other companies suggested that the individual collaboration is an important arena in which the short-term objectives for the development of a specific part need to be achieved. The second reason is that the project team needs to prepare a number of things before starting individual collaborations. Moreover, the activities and intermediate output of the various individual collaborations (e.g. prototypes) need to be co-ordinated and ultimately integrated into one final product specification package. We therefore introduced the overall project as a critical management arena. The third and final reason is that, in order to ensure that a capable supplier base is also built on the long-term and is in line with the in-outsourcing policy regarding technology and product development, we identified the strategic management level as a critical management arena. This management arena provides the balance with the short-term objectives (namely those specifically in the project plan) that drive product development projects and collaborations. In the original framework, Wynstra (1998) identified a Development Management and a Supplier Interface Management area. However, we argue that by merging them we are able to better represent the strong connection between the policy and guideline development and the creation of access to supplier resources and capabilities relevant for current and future projects. Figure 9.1 shows the three managerial arenas. Note that the Strategic management arena should support the total portfolio of development projects and, within each development project, should support the total portfolio of different collaborations. We have referred to multiple projects and collaborations using P*i* and C*i*.

Figure 9.1 Three arenas for managing supplier involvement



The second adaptation we have to the framework was to identify a basic cycle of managerial processes that follow a logical order in each of the management arenas. We argue that companies need to manage at least 18 managerial processes distributed over the three cycles. The arenas and processes are depicted in Figure 9.2.

Figure 9.2 Critical management processes for supplier involvement



Strategic Management Processes

The first process cycle concerns the execution of seven *Strategic Management Processes* (SMPs) before and during the project (see Figure 9.2). They provide a strategic direction (consisting of a technology and product development in-outsourcing policy) for project teams adopting supplier involvement. They also provide operational support (consisting of guidelines) for decision-making in project teams adopting supplier involvement, and aim to develop and maintain a willing and capable supply base to meet the current and future changing technology and capability needs. As such, these processes in the strategic management arena support the achievement of short and long-term collaboration benefits.

The SMPs improve the project performance indirectly by reducing some potentially time-consuming decision-making activities such as suggesting alternative technologies, selecting suppliers and determining the desired supplier contributions. Having invested pro-actively and systematically in the processes to work with preferred, pre-qualified and motivated suppliers in clear technological areas of collaboration, companies are better positioned to effectively involve them in development projects. They can reduce the time and costs related to searching for appropriate suppliers and understanding their exact capabilities. While the available capabilities may not result in an immediate fit, if the company knows what is missing it can mobilise internal resources to temporarily complement the weak points (e.g. by providing logistics or purchasing support to the supplier).

The processes also help to capture the long-term and strategic collaboration benefits. Several processes are critical in different ways, such as in aligning technology roadmaps and accessing relevant supplier know-how. Companies need to start to address and formulate the development of in-outsourcing policies for technological areas and product development activities. As a lever for realising and shaping this policy, companies need to monitor supplier markets, have a systematic approach to selecting suppliers in advance, and develop a preferred supplier list specifically for involvement in product development. Moreover, companies need to assess when and to what extent to use suppliers' existing products and capabilities as a starting point for developing new parts/product functions, or when to use motivational tactics to influence the supplier to invest in particular technological resources. We found evidence that evaluation processes at strategic management level allow learning experiences to be distilled. The evaluation of procedures and guidelines for supplier involvement using experiences from different projects and collaborations can help future projects to collaborate more quickly and effectively with suppliers in product development. Finally, the evaluation of the development performance of suppliers for various technological areas can be used to determine the need to change the current supplier base for a specific part category, or the need for improvement actions. The use of a shared terminology for the range of potential supplier contributions in product development is essential when discussing and aligning expectations between internal departments and suppliers regarding their role and contributions.

Project Management Processes

The second process cycle concerns the project level control for preparing, co-ordinating and evaluating all operational collaborations with suppliers in a development project. The cycle consists of six *Project Management Processes* (PMP) that form a critical link between the individual collaborations and the long-term strategic management of supplier involvement (see Figure 9.2). The first process involves the decomposition of the product architecture into functions and parts with clear interfaces, and the decision of what specific contribution in development is to be requested from suppliers. One critical activity is creating a trade-off process with the R&D, manufacturing and purchasing departments about the desired level of assembly and extent of involvement in developing the part. Alternative technologies and parts can be suggested later. In the supplier selection process for the current project, all selection criteria relevant for the project and for managing long-term risks (technological and financial dependency) must be defined. This process involves creating a cross-functional decision-making process composed of the relevant experts who can verify these criteria. Next, the level of supplier involvement for a specific part must be verified and fixed, and the appropriate phase and moment of involvement of the supplier must be determined. The co-ordination process at project level concerns the exchange of relevant design information and the proper and timely execution of development activities (e.g. prototype testing, tooling development, component quotations, contracting) between various first tier suppliers involved in developing different (interacting) parts of the final product. Finally, the overall development performance of suppliers and learning experiences for the project must be evaluated, as this can help to improve decision-making and co-ordination between different types of collaborations in similar future projects.

Collaboration Management Processes

The third cycle concerns five *Collaboration Management Processes (CMP)* (see Figure 9.2). They are aimed at designing an appropriate collaboration form, executing development activities in an individual collaboration, and learning from each collaboration episode. Collaborations are first set up with the chosen supplier by jointly determining a detailed task division including the deliverables and setting targets with a supplier. This process contributes to each other's understanding of what the nature of each contribution and the trade-offs are. Moreover, it allows the manufacturer to make the necessary preparations so that the contribution requested from the supplier is made more explicit. On the whole, it reduces the chances of misunderstandings. If the representatives from both sides and the issues to discuss are identified in advance, this helps the subsequent co-ordination of different development activities between the manufacturer and supplier(s). The operational co-ordination of the development activities then follows, given the task division and targets agreed on. The cycle is continued by evaluating the intermediate technical and commercial progress and deliverables, and ends with the evaluation of the final development performance. The evaluation of individual suppliers helps to detect barriers and aspects in the communication that need to change in a future collaboration, and can smooth possible conflicts that are lurking under the surface.

We argue that the processes in the three management areas follow basic iterative cycles, though we admit that companies may execute certain processes in parallel or skip specific processes temporarily. Even some strategic management processes may be differentiated for technological or commodity areas (e.g. motivating suppliers to develop specific products). However, in one way or another these processes do occur, either at a low or reactive level or in a systematic highly pro-active way. The time lines between the managerial arenas indicate how multiple development projects can take place (sequentially or overlapping) within the long-term strategic horizon, and how collaboration episodes with different durations are initiated within each project. The arrows indicate that the arenas are interacting and co-evolving over time by action (behaviour) of organisational members in the various processes.

This framework does not pretend to operate in a vacuum. Within a company and between the buyer and supplier other processes are at work, which are needed to manage different operational activities such as logistics, manufacturing, maintenance or order delivery. The PMPs and CMPs are clearly embedded within such processes. At the company strategic level, other strategy development processes are being carried out. The development of a market strategy, a desired product portfolio and the company's financial strategy are examples of processes that co-exist with those identified in the IPDS framework. In order to indicate how supplier involvement management is driven by, and affects, the overall company strategy, we have identified two decision-making processes. The first process concerns determining in which future markets a company wants to operate, while the second process aims at determining the current and future technology/product development capabilities. Together they provide the starting point for entering the SMP cycle for supplier involvement. As soon as the company starts reflecting and deciding where and how it wants to develop the key technologies and to carry out product development activities, the SMPs for supplier involvement are activated. The two decision-making processes truly lie at the centre of corporate strategy formulation, and are clearly connected to the technology in-outsourcing policy. Ignoring them would make the framework 'float'. However, if we add these processes to the basic framework it would make the framework too comprehensive, trying to capture 'everything'. We have therefore decided to mention them as inputs for developing strategic directions for technological areas and activities in which to involve suppliers.

We conclude that the strategic, project and collaboration management processes represent important means to use the leverage of suppliers' resources in improving the company's product development performance. However, investing in processes alone is not sufficient. Certain conditions need to be present to enable the company to carry out the managerial processes.

3. *What factors actually support the execution of processes aimed at managing supplier involvement in product development?*

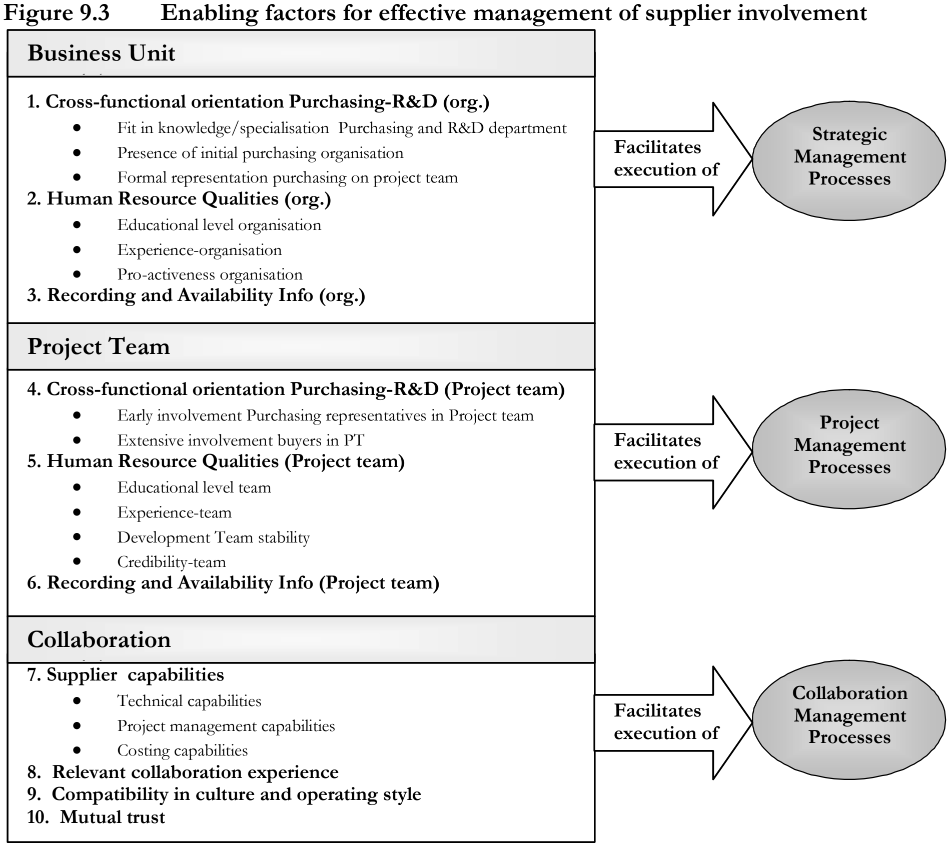
The case studies at Océ, DAP and PANalytical, Boon Edam and H.J. Heinz demonstrate that effective management of supplier involvement is fuelled by the presence of three groups of conditions. In the first group, the general organisational structure and the actual early cross-functional collaboration in a project team between Purchasing and R&D were important conditions for effectively setting-up supplier involvement collaborations. We found that early involvement of purchasing and manufacturing representatives in supplier selection can increase the chances of detecting technical, planning and commercial risks. Failing to do this resulted in resource-consuming collaborations and reconsiderations of the supplier selection or outsourcing decisions. Moreover, a decreasing commitment for supplier choices can undermine the long-term benefits.

Secondly, the quality of human resources, and the interaction between the project team members in particular, are equally important in supporting the collaboration. Special emphasis needs to be put on the engineering and the communication between the engineers and supplier. Neither a meddling approach nor a laissez-faire style is appropriate in new intensive collaborations. Von Corswant and Tunälv (2002) similarly found that many suppliers being provided high development responsibility were experiencing undesirable interference by their customer. Technical and commercial expertise, collaboration experience and credibility of both the Purchasing and R&D engineers are therefore critical in effectively co-ordinating development activities and evaluating part designs. Project team stability is also an important factor for maintaining a clear interface with the suppliers and preventing a loss of knowledge.

In the third group, we found that the management of collaborations with suppliers is further facilitated by a high level of collaboration experience, compatibility in operating style and mutual trust. It is important to note that the area of collaboration experience is equally important as the length of the relationship. The degree to which the supplier was usually involved in previous collaborations is especially important. In addition, the familiarity with engineering within certain performance priority settings and with typical production series are elements of experience that influence how effectively both parties can develop the part. Trust is both a result and an input to many decisions and actions from both sides. If there is no trust, there is no environment for learning in terms of the collaboration process and sharing of technical knowledge. If project members and managers from the buyer and supplier visit each other's organisations, this can positively influence the level of mutual trust. Perceptions based on unfounded rumours can be curbed by demonstrating the intermediate results and progress. In addition to these factors that confirm findings from previous studies, we found an additional enabling condition. In multi-technology collaborations, also project management capabilities of suppliers were critical. In those situations where a supplier is involved in the development or engineering of a 'assembly or functional module/system', its internal tasks become more complex. Engineering hours and component and material costs become important elements to plan and monitor. The selection and involvement of its second tier suppliers in component design certainly form an important ingredient for effectively managing the project with the customer.

These findings have resulted in adaptations to the original framework. We can increase our understanding of high and low-performing collaborations by identifying and analysing some extra conditions in addition to those internal enablers previously identified by Wynstra (1998). We identify three groups of conditions to make their location and their supportive role more visible in relation to the three managerial arenas: (1) *Business unit*, (2) *Project team* and (3) *Collaboration* enablers. Figure 9.3 shows the three clusters and their underlying factors.

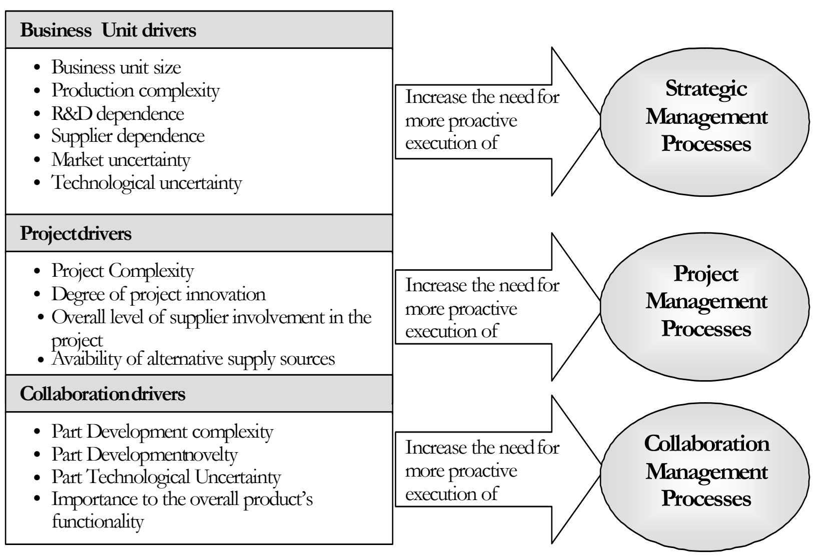
Figure 9.3 Enabling factors for effective management of supplier involvement



4. What contextual factors increase the need for executing the processes aimed at managing supplier involvement in product development?

Companies do not need to manage all supplier involvement with the same intensity and pro-activeness. We examined three different groups of factors that provide clues as to the need for specific (sets of) managerial processes. The empirical cases supported our expectation that the characteristics of the business unit, project and collaboration environments can represent risks for achieving the short and long-term objectives of supplier involvement. The sources of this risk stem from a number of uncertainty, novelty and complexity factors that need to be anticipated and responded to. For example, the consequences of introducing new technologies or concepts, or the presence of complex interfaces (hidden specifications) were not always well understood in terms of the optimal extent of supplier involvement and appropriate co-ordination of development activities. Differences in these characteristics require different approaches in dealing with the risks. We integrate three different contingency perspectives applied in previous studies. Figure 9.4 provides an overview of the characteristics and their interrelationships with the three managerial process cycles.

Figure 9.4 Driving factors increasing the need for the pro-active execution of management processes



We start by describing the context to which the whole business unit or company is exposed in terms of structural, market and technology factors. We connect these business unit level factors to the need for more systematic execution of various strategic management processes. We found confirmation that large companies that depend on innovation and on suppliers need more written guidelines to support the various departments and projects in setting up and co-ordinating collaborations. Smaller companies with lower levels of supplier involvement can resort to more informally evolving collaborations. However, a minimum presence of guidelines will make supplier involvement more organised without loosing the benefits associated with an informal organisation. Furthermore, companies exposed to fast changing technology developments and capricious consumer tastes are likely to increase their active monitoring of technological developments in supplier markets. Moreover, suppliers need to be pre-selected in order to maintain speed and create timely access to critical technologies that allow new business opportunities to be exploited. We next link the innovative characteristics of the project and the desired level of supplier involvement to the pro-activeness with which product development teams should carry out the project management processes. These processes include discussing desired develop-or-buy solutions, suggesting alternative technologies, selecting suppliers for involvement and verifying the supplier's actual level of involvement (contributions).

Finally, we connect the complexity and novelty characteristics of the individual parts to be developed with the need for collaboration management processes. Highly complex and novel parts require a great deal of attention to define clear development work-packages and targets for both parties. Moreover, in these situations, a pro-active design and communication interface with suppliers and an active (and tight) co-ordination of development activities is required to address the risks and to allow knowledge to be shared.

In general, the integrated contingency perspective simplifies and pinpoints the impact of the environment on the need for proactive attention to the design and execution of managerial processes related to product development and supplier involvement. The detailed distinction of driving factors helps us to locate different sources of risk and provide clues for specific choices and organisational arrangements supporting the collaboration. We still need to verify our hypotheses in order to determine the strength of the relationships between the drivers and the processes grouped in the three different managerial arenas.

5. *How can an analytical framework be used as a reference model for diagnosing and improving the processes and conditions underlying the effective management of supplier involvement?*

We selected and adapted an existing analytical framework to analyse the results, managerial processes and conditions associated with supplier involvement. We applied and improved the analytical framework in three iterations, in five different company contexts. The structure and the elements of the framework have proven to be helpful in analysing possible bottlenecks in the different conditions and processes not only to the researcher but also to the companies themselves. We did this by adapting the analytical framework into a computer-aided diagnostic instrument; we had a number of companies also assess their development projects and collaboration performance and relate these to the presence of conditions and processes that underlie the observed results. The colouring of the processes and conditions in the user-interface is useful in signalling where bottlenecks exist and where well-executed processes or highly supportive conditions are present. It has provided the companies involved with an integrated view of both processes and conditions critical for effectively involving suppliers in product development. One company became more aware of the risks posed by introducing new technologies and suppliers to a development project, and will more carefully consider this in advance when outsourcing development activities and selecting suppliers in the future. Other companies concluded they had paid insufficient attention to developing a clear in-outsourcing strategy, to monitoring relevant developments in supplier markets and to evaluating past collaborations. Moreover, the analysis results and the diagnostic instrument have been found to help both managers from R&D and purchasing departments to analyse strongly performing processes and possible bottlenecks in specific decision-making processes. By allowing different actors to participate in the assessment, the differences in perceptions between departments can be revealed. This helps companies to set up fruitful discussions regarding the *improvement areas* for supplier involvement. Finally, the supplier involvement typology was a useful complementary instrument to the overall analytical framework. It allowed Océ to more easily determine which contributions different departments expect from suppliers, and what preparation it needs to allow these design contributions to be realised. As such it facilitates discussions and helps to improve the way companies involve their suppliers.

9.4 Contributions to the knowledge on supplier involvement in product development

This research has demonstrated that involving suppliers in product development is a complex empirical phenomenon. The findings and answers to the research questions contribute to to theoretical knowledge on supplier involvement in product development in several ways.

The current study has addressed the fragmented view on the management of supplier involvement by providing a more holistic and integrated way of analysing the managerial processes and conditions for effective supplier involvement in the short and long-term. This was done by carrying out a theoretical and in-depth empirical validation of an existing analytical framework using an intra-organisational and inter-organisational perspective. Such a combined perspective (as argued for by Takeishi, 2001) addresses several shortcomings. Whereas previous purchasing and marketing literature (that adopted a transaction cost perspective when studying buyer-seller relationships) argued the benefits of building long-term relationships with suppliers, their focus was limited to the bilateral relationship and underlying success factors. We argue that adopting a 'relationship view' is actually 'black boxing' a phenomenon. An overall buyer-supplier exchange relationship appears to be driven by events and different collaboration episodes that together drive an evolving relationship. We therefore introduced a collaboration perspective. However, supplier involvement cannot be understood by viewing it as a buyer-supplier interaction and collaboration alone. A complementary perspective is needed, such as the intra-organisational perspective.

We adopted a managerial process perspective, thus adding to the limited number of studies that have taken such a perspective (Handfield et al., 1999; Monczka et al., 2000; Takeishi, 2001). Supplier involvement is composed of different decisions and activities that are glued together by the behaviour of different actors. By focusing on key decision-making processes and underlying activities, and by identifying the relevant areas in which they take place, we can better capture the real dynamic and complex nature of product development and collaboration. By adopting a process perspective we avoid an initial bias towards specific actors from studies on managing supplier involvement. No single actor is pre-judged as being the best at controlling or carrying out processes for involving suppliers in product development. We keep equally effective organisational solutions open for different actors to take the lead in executing managerial processes. We suggest that the question 'who should be involved in which activity' is more relevant *after* the critical processes and tasks are known. This study has provided this first step. We therefore also decided to rename the original framework 'Integrated Framework for Purchasing Involvement' (Wynstra, 1998) into the framework for 'Integrated Product Development and Sourcing'. Although Wynstra emphasises that 'purchasing' does not necessarily refer to the department, the original name of the framework does give that impression.

The second contribution to the supplier involvement knowledge is that the revised analytical framework now conceptualises the results, processes and conditions in a more realistic and detailed way; this is critical if they are to be achieved. It facilitates the structured analysis of supplier involvement in product development. In terms of results, this study has empirically examined both the achievement of short-term collaboration benefits and the creation of potential long-term collaboration benefits. By jointly considering different types of benefits mentioned by different authors in the framework, we provide a more balanced picture of the total effects and the value of involving suppliers in product development. For example, considering less-tangible benefits related to learning from previous collaboration experiences can result in an improved mutual understanding of each other's ways of working and target setting (Dyer and Ouchi, 1993). The transfer of possible innovations/solutions developed in one collaboration to other projects (Sobrero and Roberts, 2001) may increase the return on the investments in one or more of the collaborations. Furthermore, involving suppliers extensively in technologically complex or turbulent areas can also foster improved access to critical supplier know-how (Bonaccorsi, 1994; Ragatz, 1997) and better alignment of technology roadmaps (Handfield,1999; Monczka, 2000). These benefits ensure that critical functionality is introduced into your future products before those of your competitors. By jointly considering the short and long-term benefits, any below-target performance with suppliers on the short-term can be considered as a possible investment in obtaining the long-term benefits of supplier involvement.

We created a more realistic conceptualisation of managerial actions by distinguishing three instead of four managerial arenas, by defining processes based on a (re)combination of different related activities and by introducing a cyclical order in the processes. Managing supplier involvement through collaboration, project and strategic management processes gives an even better overview of the actual gears needed to balance short-term and long-term benefits and the risks. We also simplified the original framework by reducing the number of managerial processes from 21 to 18.

We have contributed to a comprehensive and detailed assessment of the critical conditions enabling the effective management of supplier involvement. Whereas previous studies identified success factors for partnership relationships and buyer involvement in product development (Ellram and Hendrick, 1993; Bruce et al., 1995; Bidault and Butler, 1998), few studies have examined them in a combined way. In the existing framework, the enabling conditions were limited to the internal factors such as the Purchasing and R&D organisation, the qualities of purchasing employees and the recording and access to information. We have identified and grouped together conditions from both previous literature and the case studies that take into account enablers at the level of the overall internal organisation, and at the level of the project team and the specific collaboration. This conceptualisation enables us to better understand how the management of supplier involvement has been supported or, when there was little management, been undermined.

A third contribution regards the consideration of 'soft issues' in managing supplier involvement in this work. Although several studies already revealed that communication is important and that mutual expectations need to be made clear in a collaboration (Bruce, 1995; Bidault and Butler, 1998), we have provided further explanations of why expectations between departments and with suppliers may differ and how they can become clear and aligned. The action research revealed that a supplier involvement management approach that pays no attention to invisible barriers is deemed to fail. Without a shared terminology that allows companies to jointly define and make decisions about expected supplier contributions, collaborations are likely to result in a cycle of corrective actions, blaming and frustrations, both internally and externally.

We also further developed and strengthened the contingency perspective in managing supplier involvement. Effective management of supplier involvement does not depend on a 'one size fits all' approach. Unlike previous studies in supplier involvement that often adopt a single level contingency perspective (Eisenhardt and Tabrizi, 1995; Ragatz et al. 2002; Takeishi, 2001; Wynstra and Ten Pierick, 2000; Sobrero and Roberts, 2001), we provide a more integrated understanding (i.e. at different managerial levels) of the different circumstances and their impact on the processes to manage supplier involvement. These different circumstances constitute sources of risk for companies that are hard to change, as such, but that need to be addressed. They are characterised by degrees of uncertainty, innovation and complexity. Analysing these sources of risk at business unit, project and collaboration level provides us with an insight into the location of the sources of risk, whether the strategy and/or project management should be adjusted, or whether a specific collaboration with a supplier needs to be managed differently (e.g. more pro-active /systematic).

The iterations between theory and empirical data has resulted in a stronger embedding of this study and the original analytical framework in the resource based view (Penrose, 1959, Wernerfelt, 1984; Barney, 1986) and specifically in the 'dynamic capabilities view' (Teece and Pisano, 1994; Teece, Pisano and Shuen, 1997; Takeishi, 2001). Until now the framework has been developed using various theoretical notions and perspectives, and using empirical observations in an eclectic way. Eisenhardt and Martin (2000), who expanded on the dynamic capabilities concept, argued that '*dynamic capabilities can be specific organizational and strategic processes (e.g. product innovation, strategic decision making, alliancing) by which managers alter their resource base'*. We contend that the revised framework has conceptualised the management of supplier involvement in product development in terms of its processes and conditions, which together form a dynamic company capability. The management of supplier involvement in product development deals with the balancing of the short-term exploitation of resource configurations between the company and its external suppliers in development projects and the long-term fine-tuning and adapting of the resource base. The processes and conditions presented in the analytical framework (IPDS), when properly executed, together form an intra-organisational capability to explore and exploit the suppliers' resources (e.g. know-how, technologies, supplier networks, financial investments) in product development, both in the short and long-term through different episodes of collaboration.

We increased the number of studies on the management of supplier involvement carried out in contexts/companies other than those in the automotive and electronics industries (Eisenhardt and Brown, 1995). We used the framework in a single high-tech company operating in the printer industry. In order to further validate the framework, we also applied it in companies operating in the construction, home appliances, analytical instruments and the food industries. This study therefore helps to reduce the bias in studying supplier involvement in the automotive and electronics industries.

Finally, this work adds to the limited number of previous studies that used sophisticated research designs combining research methods. We learnt that using a rich combination of qualitative research methods, such as longitudinal case studies and action research, allowed us to develop both a broad and in-depth understanding of the complex reality of an organisation, and especially of the dynamics in managing supplier involvement. This complexity and dynamism cannot be understood through paper alone and must involve experiencing, observing and interacting with the environment in which supplier involvement takes place.

9.5 Implications for practitioners

In this study we observed that companies striving towards increased supplier involvement can come up against numerous obstacles and disappointing experiences. The mixed success in achieving the potential benefits of supplier involvement suggest that companies have started to realise the importance of involving suppliers in the product development process, but may not yet have discovered how to successfully implement it. The insights and outputs of this thesis will help practitioners in companies to pursue supplier involvement in product development and to better understand how to manage supplier involvement, as detailed in the following recommendations.

Companies should not simply embark on a path of high and early supplier involvement without being clear about which areas it wants the supplier to contribute to and precisely what that contribution will be. You cannot expect a supplier to supply 'turn key solutions' in the first attempt. In the case studies we found that the same high level of involvement in similar functions/parts may not always be needed in different projects; each individual situation should be analysed to judge the appropriate level of supplier involvement. The longitudinal case study revealed that companies who want to involve suppliers more intensively in product development need to be able to identify and communicate the desired tasks and deliverables to be provided by the suppliers. When deciding which suppliers to select and in which areas, companies are particularly advised to use a shared terminology so that all parties understand the type of contributions that are expected from them during the product development. To be able to identify the opportunities for increased supplier involvement, it is useful to distinguish between the type of development projects and the specific design contribution that a supplier needs to provide. Developing and using supplier type classifications and a formal cross-functional organisation are necessary steps, but they are insufficient and are an inappropriate starting point. By adopting a shared terminology to use as a reference in these discussions, costly misunderstandings about roles and deliverables and the unnecessary costs of switching suppliers can be reduced, and internal commitment can be increased. The end result is that more precious time can be spent on more valuable strategic tasks (such as motivating suppliers to develop specific products and monitoring relevant developments in the supplier markets).

Companies should not neglect their own preparations that enable the supplier to provide the desired contribution. For example, a company should verify whether its functional specifications and design are mature enough to involve a supplier for feedback on manufacturability aspects. Moreover, companies should try to make their design philosophy clear to suppliers. The manufacturer may also need to adapt its specification style to allow the supplier to deal effectively and quickly with obsolete components. Communicating targets and priority setting for the overall project and for individual collaborations with the supplier can be very helpful in preventing disappointing results. For example, communicating to the supplier that design robustness is an important value can result in the supplier making different engineering choices (e.g. choice of materials) compared to parts it designs for other customers. It can also be used as one of the criteria when selecting different second tier suppliers.

Companies must have visible decision-making processes specifically associated with supplier involvement in product development. Companies are advised to employ a careful series of planning steps at strategic level, both within projects and with the suppliers themselves, to determine factors such as the appropriate collaboration area and the right division of tasks. This choice process requires an investigation, both strategically and within the project, and a discussion between the R&D, Purchasing and Manufacturing managers and the project team members. Standard and routine parts may not have to go through such planning processes, but do need to be identified early enough. Supplier involvement should be guided by a long-term and strategic direction and not by ordinances to set up high-involvement collaborations everywhere. By distinguishing between three distinct and interrelated managerial arenas, various decision-making processes can be made more visible, structured and, ultimately, can link different company representatives.

Companies should avoid a purely project-driven approach to managing supplier involvement. The success of involving suppliers in product development as a strategy depends on its ability to capture long-term benefits. If companies spend most of their time operationally in development projects, they will not be prepared and positioned to capture possible technology and learning benefits. Long-term collaboration benefits can only be captured if a company can build long-term relationships with key suppliers, where it builds learning routines and ensures that the capability sets of both parties are still aligned and are still useful for new joint projects. To obtain such benefits, companies need a set of strategic decision-making processes that help to create this alignment. Companies need to create the conditions for effective decision-making regarding the areas of collaboration, i.e., in their future technology development and product development activities. They should also pre-qualify suppliers with a specific focus on involvement in product development, and evaluate whether their supplier base is up-to-date. Companies are more successful if they have visible cross-functional as well as inter-organisational communication channels with their key suppliers; these channel and bring together information about major technological and competitive developments in the supplier markets. Two questions need to drive the building and maintaining of a supplier base: in which areas should you pursue an adaptation of your own design with technologies and products available in the supplier market, and in which areas should you influence the supplier's investment decisions to develop specific products or know-how?

To benefit from collaboration learning experiences and to transfer (innovative) solutions to other projects and future collaborations, it is critical to first set up cross-functional and inter-organisational evaluation processes to identify them. Rather than installing a steering committee for key suppliers that only meets when problems occur, the relationship can be strengthened by introducing periodic meetings between both parties' managers to discuss both short-term and long-term collaboration issues. Creating inter-organisational teams that address operational (service and logistics issues) and product development (specification, testing protocols) issues can be used to implement focused, continuous improvement efforts.

An important condition for effective supplier involvement is a cross-functional orientation of different departments that allows effective decision-making and collaboration. Relevant representatives from departments must be invited in advance of critical decisions. When selecting suppliers for substantial involvement in product development it is especially important to use cross-functional involvement, thus ensuring that the conditions for collaboration are verified. It is not only the management who should be involved, but also experts from different departments who can contribute the necessary expertise to assess the situation with the supplier. An important pitfall to avoid is a purchasing department that is pushing to become, or presents itself, as the owner of all processes and then complains that its buyers are never involved in the early and important decisions. This may signal that either the supplier's contributions are too low or that its value has been insufficiently promoted within the organisation. Based on their ambition and capabilities, purchasing departments should carefully analyse where their involvement in managing supplier involvement would be most valuable (and accepted). Purchasing departments can present themselves as a service provider with internal customers. One way of providing high added value is working with experts to build business cases for different types of collaborations with suppliers, and clearly showing any reductions in problems and any resulting benefits from involving capable suppliers. Added value is also given by fulfilling the role of commitment builder, by demonstrating the progress and intermediate output of the collaboration to managers from different departments within the collaboration. Another way of promoting and co-ordinating supplier involvement across different projects, or even business units, is by appointing a dedicated supplier involvement manager. Although not many companies have such a position, larger companies in particular can use this to create a more visible and focused effort to improve the management process and to identify more opportunities to involve suppliers in product development. For example, Schneider Electric, (a large manufacturer of equipment for electrical distribution, industrial control and automation) created such a function and appointed a heavy-weight engineer/purchasing manager to co-ordinate the initiatives across its various business units.

Seriously pursuing long-term benefits from supplier involvement needs visible support from the board of directors and must become an item on the general management agenda. For example, appointing a supplier involvement manager does not guarantee that the business units and other departments will cooperate. This is often easier said then done. Top management are only likely to support such initiatives if one or more of its board members have worked or supervised the collaboration process with suppliers in product development in the past. On the other hand, they are likely to support supplier involvement if the board is presented with clear business cases demonstrating the potential value and the likelihood of achieving it. Both purchasing, R&D and production managers must build a network of people to continuously feed the pipeline of attractive business cases for increased supplier involvement, and a routine of identifying the key benefits and risks.

Finally, companies need to carefully analyse the number of generalists or specialists it keeps within the R&D and purchasing departments. Are they able to manage a collaboration process and are they able to be a counterpart when considering and assessing technical options proposed by the supplier? Involving suppliers requires special skills and experience that fits the particular type of supplier involvement. The previous experience of engineers and buyers and their attitudes towards collaborations with an external supplier need to match with the chosen level of involvement in developing a part. For example, an engineer who continuously meddles with detailed technical choices made by a supplier, and who is asked to optimise a design from a manufacturability perspective, is clearly not for the best person to reduce development time and costs.

In combination with the above-mentioned recommendations, the diagnostic framework provides a format in which the various departmental managers can work on designing and improving critical decision-making processes. It pinpoints the generic set of critical processes and conditions in different managerial arenas, without creating an initial bias towards the involvement of a specific department. This facilitates the discussion between managers and its use as a reference model for initiating focused improvement efforts.

9.6 Limitations of the study

In addition to the positive contributions of this study, the results and insights and the ways in which they have been obtained (i.e. the research methodology) do have some limitations. The contributions and limitations of a study are closely connected, as they are the result of theoretical, conceptual choices and the methodology and methods adopted.

9.6.1 Conceptual and content-related limitations

The first potential limitation of our study is the apparent 'mechanistic' nature of the framework adopted. One could argue that the framework is too rational, thereby oversimplifying the issue. We posit that the framework helps studying critical actions and activities, also at multiple points in time. Therefore, this structure does not imply that the model is unidirectional; there are various feedback loops to consider. For example, positive long-term results can strengthen a supplier's technical and project management capabilities and therefore feeds back to create enabling conditions for the next development project.

The framework does not focus on progressions of organisations and therefore we did not study generative mechanisms (Van de Ven, 1992) of organisational change in-depth. We do address the theoretical and empirical issue regarding how companies should start implementing supplier involvement in product development (See action research project in Chapter 8). There are however additional change processes. For example, the way in which a company introduce formal representation of purchasing on product development teams. Moreover, the set-up of processes of continuous improvement with a supplier are (Coughlan etal., 2001). Such questions have not yet been fully addressed in this study. We thereby acknowledge the complex nature of involving suppliers in reality, and at the same time provide an a clearer insight into the critical processes and conditions necessary to effectively organise and manage involvement of suppliers in product development.

A related potential limitation concerns the existence of alternative behavioural perspectives on organisational processes, which are not or are less explored in this study on supplier involvement in product development. Although there is no 'wrong perspective', if you are going to study organisations in the field you need a perspective and a framework that can take into account at least one or more of the dynamic, process-related, technological, behavioural, political and cultural dimensions that characterise and affect the management of supplier involvement. For example, we can adopt political or cultural perspectives to study the same phenomenon. We have observed the possible influence of reward systems in internal departments and the availability of internal resources on the disposition of different managers to accept significant involvement of suppliers in development, engineering and assembly. Involving suppliers concerns multiple individuals and groups with possibly diverging or conflicting goals and interests, who all need to work together. Such conflicting interests may be fuelled by reward systems that do not foster more externally-generated added value. A company history of carrying out development, engineering and assembly in-house, combined with conflicting departmental goals, does not stimulate changing the extent of supplier involvement and the way they are managed. In addition, the role of professional, company and national cultures that colour, constrain or enable the effective management of, and collaboration with, suppliers in product development has received limited attention in our analysis (Hofstede, 1991; Ulijn, 1999; Trompenaars and Hampden-Turner, 1999). These cultural aspects have been partially captured in a number of enablers that concern actors such as the supplier and the purchasing and R&D departments. The addition of a political and cultural perspective would allow the impact of these factors on the effective management of supplier involvement to be examined in more depth. As such, the IPDS framework provides excellent opportunities to further deepen the knowledge of various elements at different levels of analysis within supplier involvement. The framework can therefore be seen as a menu that identifies key processes and interrelations at different levels of analysis; these are still open for different perspectives and micro theories taken from psychology, cultural, political, organisational behaviour, project management, innovation and strategy theories.

Another aspect that has received a limited amount of attention is the appropriate division of tasks and involvement of internal actors in carrying out the managerial processes in the framework. The questions of who should take the lead in carrying out specific processes and what instruments and which organisational mechanisms are most supportive for different types of companies, have not yet been answered. The fact that we have left aside these questions does not mean that they are less relevant. We have simply argued that the key managerial processes and underlying activities for managing supplier involvement must first be made clear rather than starting from a specific actor perspective.

We have made trade-offs between the measurement of the results of supplier involvement and their effects on the overall project performance. First, rather than consistently using objective data across all studies (primarily Océ), we had to resort to largely perceptual measures on an actual-to-target scale. The unavailability of archived data concerning targets or actual results and differences in measurement by companies make it very difficult to compare the actual objective performance. A compromise therefore had to be made regarding the use of perceptual measures from key informants. Furthermore, the measurement of supplier involvement results for most indicators is limited to the moment of market introduction of the end project. Although we have distinguished long-term benefits of supplier involvement, an even more complete picture of the long-term results of supplier involvement could be drawn if cost reductions/increases and quality improvements and deteriorations were measured during the life cycle of a part.

The limited assessment of the effects of supplier involvement on the overall project performance is another potential limitation. In an ideal situation, research on supplier involvement should include all collaborations that occur within the formal boundaries of a development project under study. In this way, a more complete assessment can be made regarding the effects of supplier involvement on the overall project performance. In this study we considered creating variation between project contexts and different types of parts to be at least as valuable as a full-project analysis. This choice was also driven by time and resource constraints. What we have been able to do is to examine the underlying managerial processes in-depth and to understand the results by relating the issues and problems to the way that companies carried out these processes.

This study has also paid limited attention to the management of multiple network relationships.
It is a common view that companies are part of different networks of actors that affect the ability to control and to influence the 'external environment'. In this study we have answered the call for investigations into intra-organisational decision-making processes and partially inter-organisational processes (Cyert and March, 1967), particularly in the area of supplier involvement (Takeishi, 2001). According to Van de Ven and Ferry (1980) there are three levels of analysis for studying interorganisational relationships: (1) pairwise or dyadic interorganisational relationships, (2) interorganisational sets (3) interorganisational networks. So far, the framework has primarily analysed dyadic collaborations and has indirectly examined

the role of second tier suppliers and the related managerial and organisational infrastructure. However, future research must address the possibilities of connecting these two levels of analysis to arrive at a network view of supplier involvement in product development. A more precise meaning can then be attached to the word 'managing', which as the industrial network view suggests may be closer to 'coping with' rather than 'controlling' (Håkansson, 1987; Axelsson and Easton, 1992; Håkansson and Snehota, 1995). Nevertheless, solely adopting a network view without regard for the internal managerial view would deny the necessity or ability of an organisation to start the race somewhat better prepared than other organisations. The adaptability and flexibility of an organisation and the execution of processes may be the key to capturing sustained benefits from increased supplier involvement.

Closely related to this conceptual limitation is the rather implicit measurement of interactions between the manufacturer and supplier. As Ford (1998; 4) argues, 'strategy in complex business markets is essentially an interactive process of 'coping, reacting to the actions of significant others'. The current IPDS framework partially uses an Open System logic, emphasising that the managerial processes are socially defined in their context and are interactive. Decision-making processes in particular are usually based on discussing, questioning and finding information that requires interaction between people or companies. Many of the collaboration management processes identified in the framework possess a minimum degree of interaction between representatives from both the buyer and supplier. However, the framework is not connected through a mirror process model from a supplier point of view. Dubois and Gadde (2002) argue that 'Open System studies are complicated by the fact that reality needs somehow to be delimited'. Any expansion of artificially drawn boundaries provides potential discoveries of new interdependencies and, in our case, interactions between more actors. However, instead of trying to explain the 'whole world' we have chosen to put boundaries around the phenomenon we are studying in terms of the internal and inter-organisational managerial processes and conditions.

9.6.2 Methodological limitations and reflection

There are several potential limitations concerning the validity of the research using a primarily qualitative research methodology. In general, we can argue that supplier involvement is about technical creation processes, but also a process of collaboration and strategic decision-making. Studying such phenomena needs research methodologies and instruments that allow us to observe and make sense of such a complex reality. We argued that there was an insufficient understanding of how companies can effectively manage supplier involvement in product development. This type of question has a large exploratory component. At the time we did not consider it feasible to start with testable hypotheses to answer this question. Understanding the management of supplier involvement requires the study of managerial action and decision-making in different arenas and time spaces. The research methods chosen must therefore be able to explore and reach the required observational depth.

A first potential methodological limitation concerns the extent to which an interpretative methodology was adopted that fits with the dynamic and process nature of the phenomenon. The adoption of Grounded Theory methodology (Glaser and Strauss, 1967; Strauss and Corbin, 1994) can be very suitable in situations where no clear theories or models exist that can explain the phenomenon under study. Although some theories on inter-organisational collaboration exist, we argued that the internal managerial processes and conditions had only been studied to a very limited extent. The research design reflected the need for, and ambition to, connect exploration with explanation in one research project. We chose three different types of qualitative research methods, each with certain merits and disadvantages in terms of validity and reliability. The order in which they were used is also important for the validity of the results obtained. Sheer challenges in carrying out qualitative research are how to improve the strength of the validity of what is measured and of the generalisability of the findings to a broader context.

There is certainly a risk due to the complexity of data collection and analysis. Pettigrew (1990; 111) argues that the greatest risk a qualitative researcher runs is 'data-asphyxiation'. In our first empirical study we chose a large number of case studies within the single case study company. We used a mix of retrospective and real-life case studies. Taken together, there was a real risk of data-asphyxiation. However, our research design had foreseen a number of measures to safeguard the internal and external validity of our methods and findings. We decided to use and adapt an existing analytical framework that had been developed previously, and to use it in such a way as to allow it to evolve by using a structured spiralling approach between existing literature and new empirical observations. The choice of a tentative framework grouping 'sensitising concepts' regarding the management and conditions for effective supplier involvement in product development can be considered to be an important preparatory step before observing, analysing, interpreting and concluding.

An additional potential methodological limitation of this study is the lack of a statistical generalisation of the results. We safeguarded the generalisability of the findings by using analytical generalisation (Yin, 1994) and applying the analytical framework in multiple contexts, comparing them and referring back to literature. We also paid explicit attention to the different steps and procedures used both in the combination and in the individual execution of the qualitative research methodologies (case studies and action research). This means that our results provide in-depth insights into how companies that develop and manufacture tangible products can effectively manage supplier involvement in product development. Action research allows us to derive in-depth knowledge of whether designed solutions work in practice, and to discern bottlenecks in implementing parts of the framework or the framework as a whole. Although the external validity is not guaranteed, it also allows us to develop more precise hypotheses about the relationships between processes and conditions for effectively managing supplier involvement in product development. We argue that the combined use of case and action research has served both the purpose of exploration and explanation, i.e., describing and understanding how things work. What is critical is the process of creating an evolving framework (Dubois and

Gadde, 2002) in which theory and practice speak to each other and arrive at a more precise understanding of important constructions and likely relationships between them. Such research can and should evolve towards more hypotheses to generate and test the type of research.

Finally, we describe the important ingredients in each of the empirical studies to ensure the validity of the methodologies and findings. In our first empirical study we combined structured and pre-arranged interviews with a regular presence in the arena where the management of supplier involvement takes place. The longitudinal case study, during which eight cases of manufacturer-supplier collaboration were developed, presented a tremendous opportunity to go one step deeper into the history and the issues occurring when managing a variety of collaborations. It allowed us to build explanations by consulting people who were directly and indirectly involved. Moreover extra in-depth observations could be made through informal 'chats' on site. Combining such structured and unstructured forms of data collection often allowed us to fill in the gaps and verify earlier statements by interviewees. By combining these issues and analysing them from the viewpoint of previous literature, we were able to obtain a more complete picture about the period before, during and after the collaboration. We also had the opportunity to talk to the suppliers themselves. Again, this allowed us to understand certain events from both sides. The physical presence of the researcher at the company still allowed us to preserve enough distance between subject of research and the researcher. A continuous awareness was maintained to prevent the respondents from influencing the observations too much resulting in short-sightedness. Being close to the organisation allows those involved to talk 'freely' to the researcher about the topic under investigation. However, a certain level of trust first needs to be established. The presence of various sponsors has been crucial in creating the initial access and trust. During these last four years I have kept this issue in mind when interacting with company employees.

The execution of an additional series of four case studies fitted well with our question to assess the extent to which the revised analytical framework could be applied in different contexts. A critical step for us in gaining more in-depth understanding of the way these companies managed supplier involvement was the use of triangulation of data collection methods through a small survey and with interviews to assess the processes and conditions. Industry differences (such as production type) were partially taken into account in our analysis.

Based on my experience, action research is one of the most challenging research methodologies to carry out, even more so than case research. It is the most evident example of the researcher intentionally intervening and interacting with the organisation and people working within it. It involves developing and testing a guideline and solution for a particular problem, where the researcher is accountable for the effect it has on the organisation. One critical step in action research is the selection of the 'issue' or problem to be further examined and improved. Once the issue has been selected it should not result in a 'simple consultancy' job, i.e., where the researcher fixes the problem for the company. We assured that in the action research process itself the emergent insights have been compared to existing literature in an iterative fashion. The researcher will always need the cooperation and support of people within the organisation. We therefore ensured the relevance of the issue for at least one group of people affected by, or involved in, managing supplier involvement.

9.7 Recommendations for future research

Research on the phenomenon of supplier involvement is still needed to address the remaining issues that can be derived from the limitations described in the previous section.
We first suggest that the skills of, and the interaction between, key representatives in the functional and project organisation in companies' outsourcing processes need to be further examined. The management of supplier involvement at strategic, project and individual collaboration level requires decision-making and collaboration among individuals who operate in strategic management, functional and project organisations. Besides a number of contributions on buyer traits and skills (Anklesaria and Burt, 1987; Atuahene-Gima, 1995), more research is needed into the personal qualities of managers and project members when managing different elements of supplier involvement.

Further investigation is also needed into the appropriate informal and formal mechanisms that enable effective learning across different departments and with suppliers in the context of higher supplier involvement in product development. In the current study we observed that one of the potential benefits of starting to involve suppliers in product development is the potential for learning, making future collaborations less resource-consuming and more effective. Still, many companies make the same mistakes over and over again. We therefore argue that visible evaluation processes need to be in place at different organisational levels to allow learning experiences to be passed on. However, there are more organisational measures that allow local learning experiences (in the minds of those who were directly involved) to be shared and transferred to other parts of the organisation and the supplier involved. Informal socialising mechanisms and co-location of supplier engineers (guest engineering) in the project team were frequently mentioned (Lewis Slack and Twigg, 2001; Monczka, 2000; Lamming, 1994). The question is whether they are effective in improving processes across departments and suppliers. For example, how does an organisation spot and use an effective engineering style used in one of its collaborations with suppliers? If this approach entirely depends on one person, the question is how the company can exploit this knowledge in a wider organisational context? If companies adopt a strategy of increasing supplier involvement, it is very likely that they will require a different way of defining their product architecture and specifying the functions and underlying components. How can a company unlearn, and how far does it need to unlearn, its specification routines and knowledge about the function and its production technologies?

The role of target setting and reward systems in supporting or undermining supplier involvement in product development should be examined. The current framework has not captured and conceptualised the role of target setting and reward systems as an enabler (or barrier). We can argue that the target setting and reward systems should favour overall process optimisation and not local efficiency. Reward systems can heavily influence the disposition, commitment and behaviour of people towards increased supplier involvement. Applying earlier research on the effect of rewards systems now in the area of supplier involvement can generate important insights in how to create an organisation that is prepared and willing to analyse and act on opportunities of supplier involvement.

Additional research is needed to investigate the opportunities and different requirements for managing supplier involvement in markets characterised by different degrees of market and technological turbulence. The study by Eisenhardt and Tabrizi (1995) argue that different industrial and market environments are characterised by different 'paces', different product development models (compression versus the experiential approach) may be more appropriate. This is also likely to have consequences for the appropriate supplier involvement project management approaches. Based on our insights from the case study between Océ and a PC supplier, it would also be worthwhile examining managerial requirements for involving suppliers who are currently active in a high pace (velocity) environment, in a lower pace development context. This calls for more in-depth examination of the internal organisational arrangements procedures and information technology that facilitate the execution of the managerial processes in the three arenas. A number of authors (Sobrero and Roberts, 2002; Wynstra and Ten Pierick, 2000) have already suggested different governance mechanisms at collaboration level, which can therefore be connected to the processes of determining the communication interface between the buyer and supplier involved. Furthermore, future research could focus on the question of 'who should take the lead in carrying out the different managerial processes'. A cross-functional organisation does not necessarily mean that different internal actors cannot take the lead in different processes.

The current study should be extended to include research on how to foster innovation through parallel, collaborative action in supply networks. Besides the involvement of customers (Von Hippel, 1988) in generating and improving innovations, soliciting and integrating innovations driven by multiple suppliers is another area that warrants further research. For more innovative product development and speed, companies find themselves increasingly dependent on creating access to innovations from multiple suppliers. Due to the increasing specialisation, such capabilities need to be mobilised and development activities need to co-ordinated among groups of suppliers. The problem is that not every company and supplier shares the same interests. It would be valuable to look more closely at the ways in which companies can effectively mobilise resources from networks of cooperating suppliers, by creating a collective ambition and designing effective co-ordination mechanisms. In this respect, we invite researchers to combine the industrial network perspective with a focal company perspective.

Finally, more interdisciplinary studies on supplier involvement should be set-up. As we have observed, management supplier involvement requires truly interdepartmental collaboration and co-ordination. The processes are executed at the point where political, strategic, information technology and cultural aspects become blended into managerial action. For example, the increasing internationalisation of the supply base (Mol, 2001) has increased the importance of the effective and efficient management of cultural differences and the use of information technology when involving suppliers in product development. Having multiple researchers from different backgrounds working on key questions and examining them using an integrated perspective will help us to further unravel how and why supplier involvement fails or succeeds. Both longitudinal case studies and action-research methodologies would be valuable in order to fully examine the inter-organisational and internal processes.

9.8 Final Remarks

I carried out this study in the fascinating area of supplier involvement in product development. Both companies and researchers have attempted to catch and study the benefits of more supplier involvement earlier on in the product development. We now know that both the practical and research journeys are not simple. Why not? Because developing products is a complex business process. This complexity is only heightened by the need to do it faster, better and at a lower costs. Companies are realising that they cannot develop products by themselves; to keep their knowledge up to date they would need to keep up with external developments and the related high investments. If they are to continue filling the new product pipeline, it is vital that they use innovations from other markets and companies. The key issue in involving suppliers is no longer whether or not to do it, but how to be better than your competitors. In other words, you can better concentrate on how your suppliers' knowledge and skills can be utilised and integrated, and on developing the involvement of suppliers as a company capability. This study will help companies to shift suppliers into the right gear in developing new and improved products. By performing the managerial processes and developing the conditions for effective product development it can benefit from the leverage in improving product development performance. The managing of supplier involvement requires a careful balancing of short-term and long-term product development interests. A supplier's knowledge and skills should not simply be thought of as having a 'high-tech' nature. Their ability to bring in ideas at the design stage, reducing logistics costs and handling speeds, can be as valuable as developing a complex integrated circuit with double the previous functionality. This study was one step at the very beginning of a journey to comprehend the intricate and complex reality of involving suppliers in product development. I foresee many follow-up studies that will help companies in their quest for continuous performance improvement and help science to learn increasingly more about this phenomenon.

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Appendices

Appendix 4.1 Overview of interviews Océ[1]

Departments	General	Optics Unit Wide format 1	Optics Unit Wide format 2	PC-Based Controller	Paper Separation Assy	Optics Unit Small Format	Power Supply	PRU	MSU
R&D director	1								
R&D Vice President Mechanical Engineering	1							3	3
Manager R&D Mechanical Engineering	1							4	4
Vice President R&D Electronics	2		1			1	2		1
Manager R&D Electronics	1								
Vice President R&D Systems				2					
Project Secretary	1								
R&D Competitive Intelligence	1								
Development engineer		2	1	2					
Mechanical Engineer project		1	1		2	1		4	
Electronics Engineer		1	1	2		1	4		1
R&D Project Leader		1	1				1	3	4
R&D Outsourcing project leader								1	1
Service Engineer					1				
Manufacturing and Logistics President	1	1							
Vice-President Manufacturing	1	1		1				2	2
Manufacturing Engineer 1		1	1			1		1	1
Manufacturing Engineer 2		1	1			1			

[1] Table indicates the number of times pre-arranged conversations/interviews have taken place in the period 1 Oct. 2003 – 1 May 2003 to discuss about a general Océ organisation and strategy or about a specific collaboration. This table excludes interviews for action research (Appendix 8.3).

Overview of interviews Océ continued

Departments	General	Optics Unit Wide format 1	Optics Unit Wide format 2	PC-Based Controller	Paper Separation Assy	Optics Unit Small Format	Power Supply	PRU	MSU
Manufacturing Engineer 3			1						
Manufacturing Project leader	1	1	1			1		2	2
Strategic Planning WFPS	2								
Strategic Planning PCP	2								
Marketing	1								
Supplier Quality Assurance	4			2					
Vice-President Purchasing 1	1								
Vice-President Purchasing 2	2								
Vice-President Purchasing 3	2							1	1
Project Purchasing Coordinator			1	1				1	1
Account Buyer 1 Machines		3	3	2	2	2	2	2	3
Account Buyer 2 Machines		1	1	2	2	1	2	3	2
Purchasing Manager Electronics	2								
Account Buyer Consumables	2								
Logistics Manager	1								
Supplier Managing Director								1	
Supplier project leader		1	1	1		1		1	1
Supplier account manager		1	1	2		1		1	1
Supplier manager project-organisation								1	1
Supplier Engineer 1		1	1			1		1	1
Supplier Engineer 2		1	1			1			
Océ-Supplier intermediary		1	1			1			
Supplier purchasing								2	2
Total (183)	**30**	**19**	**19**	**17**	**7**	**14**	**11**	**33**	**32**

Appendix 4.2 Interview Questionnaire Case studies Océ

Date:...
Name respondent:...
Function at the time of involvement in the development project:......................................

Introduction

Survey questions

A1 Is your company dependent on the knowledge and capabilities of suppliers for the development of new products? (Core-technologies, production techniques, engineering expertise, testing, prototyping or technology integration expertise...)

not at all barely somewhat considerably completely

A2 Is it in your opinion important that purchasing activities are clearly and early co-ordinated with the development of new products (desired state)?

not at all barely somewhat considerably completely

A3 Is there at your company a clear and early co-ordination between purchasing activities and the product development process (actual situation).....

not at all barely somewhat considerably completely

A4 Should there be efforts to increase this co-ordination?

not at all barely somewhat considerably completely

A5 To what extent is the R&D department satisfied with the role of the purchasing department in product development? **(answer by representative Purchasing department)**

not at all barely somewhat considerably completely

A5 To what extent is the Purchasing department, in your opinion, satisfied with the opportunity and room they get from your department to provide added value to the development process.**(answer by representative R&D))**

not at all barely somewhat considerably completely

A6 Does the purchasing department get enough opportunity and room from the R&D department to provide added value to the development of new products? **(answer by representative Purchasing department)**

not at all barely somewhat considerably completely

A7 Is your department satisfied with the role and activities of the purchasing department in the development process for new products? **(answer by representative R&D)**

not at all barely somewhat considerably completely

Introduction *(continued)*

Open questions

1 What activities do purchasing or R&D currently perform that in your eyes add value to the product development process (which don't?)

- ....
- ....
- ....

2 When should these activities be carried out (within projects, across projects, permanently)?

3 What additional activities could purchasing R&D possibly carry out that would support the product development process. (which project or company targets would be Improved?)
Please write down the *desired* activities

4 When should these activities be carried out? (Please indicate per activity whether they should be carried out within projects, across multiple projects, permanently; multiple answers are possible)

Development management

Survey questions

B1 To what extent does your department take part in discussions and decisions on keeping certain technological knowledge in-house or not? (Both materials, product technologies)

not at all barely somewhat considerably completely

B2 To what extent does your department have clear guidelines and objectives regarding its own responsibilities and tasks in product development?

not at all barely somewhat considerably completely

B3 To what extent has your company clear guidelines and objectives regarding responsibilities and tasks of suppliers in product development?

not at all barely somewhat considerably completely

B4 To what extent have these guidelines and objectives been clearly communicated to other departments

not at all barely somewhat considerably completely

B5 To what extent have these guidelines and objectives been clearly communicated to suppliers?

not at all barely somewhat considerably completely

Open questions

1. Please describe the general guidelines and objectives regarding Océ develop or buy strategy?

2 How have these guidelines and objectives been communicated?
- internally (R&D, Purchasing, others?)
- externally (suppliers)

Supplier Interface Management

Survey questions

C1 To what extent does your department carry out market research specifically targeted at technical information and developments?

no never seldom quite often yes, always

C2 Does your department maintain a base of preferred suppliers for which the abilities for co-operative product development are an important criterion?

no, not at all barely to some degree yes, permanently

C3 Does your department encourage or motivate suppliers to build up knowledge or develop products in those areas where your company needs it.

no never seldom quite often yes, always

C4 Does your department try to exploit the full potential of the specific technical knowledge and capabilities of suppliers?

no never seldom quite often yes, always

C5 Does your department evaluate the development performance of suppliers

no never seldom quite often yes, always

C6 Are these specific "development" evaluations considered in general ratings of suppliers?

no never seldom quite often yes, always

Open questions

1. Has the supplier been selected following from market research carried out by your department? (R&D or Purchasing? and which department within both?)
2. Has the supplier been pre-selected outside of any projects as a development partner?
3. Has this supplier been motivated to build up or maintain specific knowledge for the outsourced product?

- Type of knowledge?
- how?

4. Did you and how did you exploit the technical capabilities of this supplier? (Adapting product design/configuration by taking into account strengths and specialties of this specific supplier?

5. How is "development performance" of this supplier for this project being monitored/measured?
   - What aspects are measured or alternatively discussed?

6. How are these evaluations included in the supplier rating?

7. According to you what have been the most important issues or problems related to the topics in the previous questions?

Project Management (planning)

D1 Does your department participate in project-specific Develop-or-buy discussion and decisions?

no never seldom quite often yes, always

D2 Does your department - within the frame of a specific project - decide which suppliers are to be involved.

no never seldom quite often yes, always

D3 Does your department - within the frame of a specific project -decide to what extent involve suppliers?

no never seldom quite often yes, always

D4 Does your department - within the frame of a specific project - decide at which moment the suppliers will be involved.

no never seldom quite often yes, always

Project Management (planning) continued...

Open questions

1. How has the supplier been selected?:
   - Has there been a develop or buy issue?
   - (existing supplier, part of competitive bidding procedure, sole source, selection criteria?)

2. By whom? (Which function had the final say, who put this supplier forward for the first time?)

3. In which project phase has this supplier been selected? How many weeks after start of this particular phase was the supplier selected?

4. When, during which phase, began the involvement of this particular supplier?

5. When were <u>you</u> and when was <u>purchasing</u> first involved in this outsourced product development?
   - Your involvement = Phase .... (please circle: early, mid or late)
   - First Purchasing involvement = Phase ....(please circle: early mid, late)

6. Could you describe what this involvement consisted of at the beginning? (Extent of involvement)

   <u>Design maturity</u>
   The involvement of suppliers in development of a certain component can differ depending on the degree of design responsibility assigned to the supplier. The following categories can be distinguished:

i	detailed controlled components	Production engineering
ii	Detailed/global design	Product engineering (with help of Océ proto's and some drawings)
iii	global design	Grey box (large responsibility in design but still control of PDP by Océ)
iv	Functional specs	black box (Océ doesn't control PDP)

Additional responsibilities for the supplier (for example: testing activities)

- ....
- ....
- ....

7. Has the extent of involvement changed during the project?

   <u>reasons,:</u>
   - ....
   - ....
   - ....

enablers (for example what made it possible to give the supplier more input in the design, engineering phase?:

- ....
- ....
- ....

8. How has the above described extent of involvement been defined.

   - Followed by previous experience with this supplier
   - rules from practice (all other experiences with suppliers)
   - followed official workingprocedure
   - ad hoc

9. Has the project experienced delays if yes please describe them and the underlying causes?

10. How and who has succeeded in turning around these delays? Can you describe the acceleration techniques?

11. Have you experienced changes in planning of the development of this outsourcing project as a result of changes in the project-defintion or delays in other development areas of the project?

12. According to you what have been the most important issues or problems related to the topics in the previous questions

Project Management (execution)

Survey questions

E1 Is your department responsible for the co-ordination of development activities between suppliers and internal departments?

no never seldom quite often yes, always

E2 Is your department responsible for the co-ordination of development activities between different first tier suppliers or direct suppliers?

.

no never seldom quite often yes, always

E3 Is your department responsible for the co-ordination of development activities between 1st and 2nd tier suppliers?

no never seldom quite often yes, always

E4 Is your department responsible for chasing proto-types made by suppliers?

no never seldom quite often yes, always

Open questions

1. How has co-ordination of involvement taken place in this outsourcing project?
   - Has Océ defined relationships co-ordination roles/responsibilities for several constellations of suppliers: like Océ <--> first tier supplier,
first tier <--> first tier supplier,
first tier <--> second tier suppliers etc.).
   - Who decides on allocation of co-ordination responsibilities?

2. What kind of communication structure has been put in place? (i.e. standard or project/supplier specific?)

   - How many persons in each company speak with each other (their respective functions?)

3. How did co-operation take place during project?
   - supplier location during project (all the time at outsourcing company or periodic meetings at supplier premises/ video-conferencing etc.

4. How did supplier proto-type management take place in this outsourcing project?
   - who ordered, chased and monitored planning of supplier prototypes?
   - how?

5. Can you tell more about the design changes in every phase and associated problems?

   - What categories of design changes were the most important for the outsourcing project?
   - What categories of design changes were the most important for the copier project as a whole (All other development areas in the project included)

6. Have discussions about tooling taken place in the outsourcing project (either for testing or assembling or production) ?

   - What was the project's policy: soft tooled parts or hard tooled parts?
   - What have been the arguments for a particular choice in this specific project!!!
Has the decision been changed ? (reversed?)

7. According to you what have been the most important issues or problems related to the topics in the previous questions

Project Management (execution)

F1 Within a specific development project, does your department provide information regarding new products and technologies developed by suppliers?

no never seldom quite often yes, always

F2 Does your department analyse in an early stage of a development project the availability, development time quality and costs of supplier parts?

.

no never seldom quite often yes, always

F3 Within a specific development project, does your department suggest alternative suppliers, products or technologies that could result in a better more innovative, cheaper, or faster to develop the final product?

no never seldom quite often yes, always

F4 Does your department actively promote standardisation and simplification of supplier parts of new products?

no never seldom quite often yes, always

Open questions

1. Has there been any activity with respect to providing information on new products and technologies before the supplier had been chosen? (info on technologies embodied in the product.)

   - Who gave info to whom? Purch->R&D, R&D-> purchasing, Purchasing-> supplier or R&D->supplier

2. Has there been any suggestion from somebody that this particular product or technology would increase quality, lower costs etc?

   - What were the perceived benefits of this product?

Appendix 4.3: Overview participants case study validation workshop Océ

Cases	Operational participants group	Strategic management participant group
Optics Unit WF1 and SF	1. Manufacturing Engineer Beta project 2. Account buyer Beta project 3. Electronics engineer Beta project 4. Optics development engineer Star project 5. Development engineer Beta project	9. Purchasing Commodity Manager 1 10. Purchasing Commodity Manager 2 11. Engineering Manager Electronics 12. Mechanical Engineering Manager Manufacturing Project Leader Beta project 13. Manufacturing Project Leader Delta project 14. R&D project leader Beta project 15. R&D project leader Delta project
Moving Stapler Unit	6. Account buyer Delta project 7. Development engineer 1 finishing system Delta project 8. Development engineer 2 finishing system Delta project	

Appendix 5.1 Detailed collaboration results eight Océ cases

Optics Unit Wideformat I (Star project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional Performance				■		The technical specifications did not match with expected functional behaviour, Optics Units were initially not 100% reliable based on field returns. However its functional performance levels contributed strongly to the final printing performance in combination with high speed
	Reliability		■				
	Durability		■				
	Conformance to specifications	■					
Part Cost	Initial cost target to contract price	■					At the time of market introduction there was a higher price than the target. However, the performance was much better than the first collaboration
Part Development costs	Nr of Engineering hours	■					Was not really an issue given the stakes, but more efforts from both sides had to be put in realising the objectives than expected
	Prototype costs		■				The supplier development costs were largely incorporated in prototype prices
Part development time	Conformance to overall project planning		■				Project was somewhat delayed but cannot uniquely be attributed to this specific collaboration
	Conformance to intermediate prototype planning		■				The intermediate planning was sometimes stretched due to unexpected technical problems

1 = much worse than target; 2 = slightly worse than target; 3 = on target; 4 = slightly better than target; 5 = much better than target

Optics Unit Wideformat II (Moon project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional Performance			■			The reliability of the mechanical design was considered risky and was solved during the project. Océ had to provide more design input on electronics and mechanical aspects than expected. In the end, the Optics Units delivered for production were performing well.
	Reliability		■				
	Durability			■			
	Conformance to specifications			■			
Part Cost	Initial cost target to contract price						The part cost was slightly higher than the initial targets in the project plan, but was under control.
Part Development costs	Nr of Engineering hours			■			No significant budget overruns were reported. There was no dedicated internal engineering capacity for this particular Optics Unit
	Prototype costs		■				Because of the redesign some extra prototypes had to be ordered, but did not much increase the development costs
Part development time	Conformance to overall project planning			■			Moon project was delayed but cannot be attributed to this specific collaboration
	Conformance to intermediate prototype planning			■			No, The intermediate planning was sometimes stretched due to unexpected technical problems

1 = much worse than target; 2 = slightly worse than target; 3 = on target; 4 = slightly better than target; 5 = much better than target

PC-based controller (Moon project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional Performance			■			The initial PCs and its components were not 100% validated for application as an embedded system in a printer dataprocessing environment Field problems were recorded, that pointed to reliability, durability. Moreover non-conformance to specifications were initially encountered (Labels, keyboards, Océ specified PBA)
	Reliability		■				
	Durability		■				
	Conformance to specifications		■				
Part Cost	Initial cost target to contract price			■			The part cost was initially on target. Later upgrades from an end-of-life PC to a Workstation caused the part cost to rise.
Part Development costs	Nr of Engineering hours		■				Engineering hours were necessary to test the PC in the Océ printer and software environment. Océ R&D could hardly keep-up with the pace at which tested PC's had to be replaced and tested again by new PC versions
	Prototype costs		■				PC prototypes more than expected costs but not the largest cost driver
Part development time	Conformance to overall project planning		■				The PC-based controller was challenging the planning, but was not a bottleneck. Technical Problems elsewhere caused overall delay
	Conformance to intermediate prototype planning		■				Cycles of testing were going faster than the overall machine prototype cycles. This created some problems for the project team.

1 = much worse than target; 2 = slightly worse than target; 3 = on target; 4 = slightly better than target; 5 = much better than target

Paper separation assembly (Alpha project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional Performance		■				The rubber roll in combination with the plastic core was a variable source of reliability and durability problems. Although the separation function worked well for some period, the high interaction with the sheets of paper, the increasing variety of new types of paper put great challenges on finding the right functional and process and assembly specifications. Field problems occurred when the supplier moved production. Although the supplier thought it produced the roll exactly according to spec.
	Reliability	■					
	Durability	■					
	Conformance to specifications		■				
Part Cost	Initial cost target to contract price					■	The cost was in absolute terms low and better than target
Part Development costs	Nr of Engineering hours		■				More engineering hours were used than anticipated because of emergent functional problems during the project. They were triggered by the increasing variety of papers that the separation assembly should be able to handle
	Prototype costs		■				Were not significant
Part development time	Conformance to overall project planning			■			The Alpha project was delayed but a variety of problems elsewhere were together responsible for the overall delay but cannot be attributed to this specific collaboration
	Conformance to intermediate prototype planning		■				The growing awarenss the separation functionality was not at desred quality level caused some initial delay. The subsequent engineering prototype cycles were in line with the planning

1 = much worse than target; 2 = slightly worse than target; 3 = on target; 4 = slightly better than target; 5 = much better than target

Optics Unit Small Format (Beta Project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional Performance				■		The technical specifications did not match with expected functional behaviour, Optics Units were initially not 100% reliable based on field returns. However its functional performance levels contributed strongly to the final printing performance in combination with high speed
	Reliability		■				
	Durability		■				
	Conformance to specifications	■					
Part Cost	Initial cost target to contract price	■					At the time of market introduction there was a higher price than the target. However, the performance was much better than the first collaboration
Part Development costs	Nr of Engineering hours	■					Was not really an issue given the stakes, but more efforts from both sides had to be put in realising the objectives than expected
	Prototype costs		■				The supplier development costs were largely incorporated in prototype prices
Part development time	Conformance to overall project planning		■				Project was somewhat delayed but cannot uniquely be attributed to this specific collaboration
	Conformance to intermediate prototype planning		■				The intermediate planning was sometimes stretched due to unexpected technical problems

1 = much worse than target; 2 = slightly worse than target; 3 = on target; 4 = slightly better than target; 5 = much better than target

Heater Power Supply (Gamma project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional Performance				■		The power supply worked well and solved the potential problem of non-compliance with new norms. Supplier was experienced in dealing with Océ specific requests and adaptations. The supplier responded quickly
	Reliability			■			
	Durability			■			
	Conformance to specifications			■			
Part Cost	Initial cost target to contract price		■				Cost was under control according the buyer and engineer, but received in the years after market introduction more attention.
Part Development costs	Nr of Engineering hours			■			Targets were not very stringent, problem had to be solved
	Prototype costs		■				No significant costs, although the total prototype costs as such was not a critical item for the project.
Part development time	Conformance to overall project planning			■			The development of this part did not slow down the overall project planning.
	Conformance to intermediate prototype planning			■			Involvement upfront and early during the project allowed timely availability of prototypes and of the final part

1 = much worse than target; 2 = slightly worse than target; 3 = on target; 4 = slightly better than target; 5 = much better than target

Moving Stapler Unit (Delta project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional performance			X			The end result is satisfactory. But intermediate prototype quality required extra effort more than expected. Reliability and durability and safety were aspects that remained issues during some time during the collaboration.
	Reliability		X				
	Durability			X			
	Conformance to specifications			X			
Part Cost	Initial cost target to contract price		X				Material costs are better than target However, no clear overall target setting
Part development costs	Nr of Engineering hours	X					Significant overruns were recorded on both sides. In hindsight this is called 'learning money'.
	Prototype costs		X				More prototype cycles than expected therefore higher prototype costs but not substantial
Part development time	Conformance to overall project planning			X			Has not been on the critical path.
	Conformance to intermediate prototype planning			X			However, the expected iteration between intensive collaboration and periods without much communication put pressure on the planning on both sides

Print Receiving Unit (Delta project)							
Collaboration objectives	**Performance elements**	**Perceived degree of target achievement**					**Comments**
		1	2	3	4	5	
Part Technical Performance	Functional Performance			X			The function has suffered intermediate functional and Durability problems. However, these problems were improved in the collaboration with Sorto. Some doubts existed about Sorto's ability to conform to the tight tolerances when assembling the PRU, but proved to be unjustified
	Reliability			X			
	Durability		X				
	Conformance to specifications			X			
Part Cost	Initial cost target to contract price		X				Material costs are better than target, Overall contract price is acceptable for Océ. However, no clear overall target setting at the beginning
Part development costs	Nr of Engineering hours		X				The overall development of the PR, it has costed more engineering hours than budgetted. The engineering budget in the collaboration with Sorto was largely under control
	Prototype costs		X				Prototype costs were
Part development time	Conformance to overall project planning			X			Development could benefit from overall project delay
	Conformance to intermediate prototype planning		X				Some moments were observed in which the intermediate prototype planning was not met in the first collaboration w

Appendix 7.1 Basic framework elements and underlying items

Based on the adaptations introduced in Chapter 6 we have further detailed the proposed variables for the results, processes and conditions. The questionnaires used in the cross-sectional case studies have been based on this 'operationalisation'.

Appendix 7.1a Results

	Variable	Items (questions)
Short-term Project results	**Final Product Quality**	Compared to target
	Final Product Cost	Compared to target
	Final Development costs	Compared to target
	Time-To-Market	Compared to target

	Variable	Items (questions)	Items (questions)
Short-term Collaboration Results	**Part Technical Performance**	Supplier X compared to target	Share of the total number of suppliers involved have performed worse/similar/better on Part Technical performance compared to targets set at the beginning
	Part Cost	Supplier X compared to target	Share of the total number of suppliers involved have performed worse/similar/better on Part costs compared to targets set at the beginning
	Part Development costs	Supplier X compared to target	Share of the total number of suppliers involved have performed worse/similar/better on Development costs compared to targets set at the beginning
	Part Development Time	Supplier X compared to target	Share of the total number of suppliers involved have performed worse/similar/better on Development time compared to targets set at the beginning

	Variable	Items (questions)	Items (questions)	Items (questions)	Items (questions)
Long-term Collaboration Results	**More efficient and effective future collaboration**	Expected extent of occurrence of Faster development speed in future collaboration	Lower development costs in future collaboration	Better performing designs (e.g. higher value-price ratio) in future collaboration	Lower cost (e.g. lower life cycle cost of components or modules) in future collaboration
	Improved access to supplier's know-how	Expected extent of occurrence of LTCR			
	Improved alignment in technology roadmaps	Expected extent of occurrence of LTCR			
	Transfer of solutions to other projects	Expected extent of occurrence of LTCR			

Appendix 7.1b Strategic Management Processes

Element	Variable	Item (question)	Item (question)	Item (question)	Item (question)
Strategic Management Processes	SMP 1	Formulating guidelines for internal departments on how to manage supplier involvement in the product development process.(supplier selection instructions, instructions for use of purchasing portfolio for a development project)	Formulating guidelines for external suppliers on how to collaborate with your business unit in the product development process (instructions on project planning format and project agreement elements, drawing standard)	Communicating guidelines for internal departments on how to manage supplier involvement in the product development process.(supplier selection instructions, instructions for use of purchasing portfolio for a development project)	Communicating guidelines for external suppliers on how to collaborate with your business unit in the product development process (instructions on project planning format and project agreement elements, drawing standard)
	SMP 2	determining which technology development activities to outsource to suppliers.	determining which product development activities to outsource to suppliers.		
	SMP 3	scanning supplier markets for competitive developments (e.g. new entrants, regulations etc.).	scanning supplier markets for emergence of alternative technologies.	scanning individual suppliers currently in your supply base for specific developments (e.g. technical, commercial and ownership developments).	
	SMP 4	pre-qualifying suppliers	building a list of Preferred Suppliers for involvement in product development.	evaluating innovation-related capabilities of suppliers (e.g. supplier engineering capabilities, investment by supplier in own R&D).	involving suppliers in technology development activities for application in future product development projects.
	SMP 5	applying technical standards being developed in supplier markets when designing new products.	using elements (e.g. components, modules) already available in supplier markets when designing new products.	taking future supplier capabilities as a starting point in developing the Business Unit's technology roadmap.	
	SMP 6	influencing suppliers to focus their resources on specific technological areas, bringing this in line with your Business Unit's technology roadmap.	influencing suppliers to develop specific elements (e.g. components, modules), bringing this in line with your Business Unit's product roadmap.		
	SMP 7	evaluating periodically suppliers' development performance to update the preferred supplier base".	reviewing guidelines on how to organize collaboration with suppliers in the product development process.		

Operational Management Processes

Element	Variable	Item (question)	Item (question)	Item (question)
Operational Management Processes	OMP 1	Project team actively involved in identifying upfront the different building blocks of the final product for which development activities were planned to be outsourced to external suppliers.	Project team actively involved in defining the preferred supplier development responsibility regarding the various building blocks of the final product (before the supplier is chosen).	
	OMP 2	Project team actively involved in collecting suggestions from suppliers on alternative technologies or components during the product development process	Project team actively involved in comparing alternative suppliers and their technologies or components for further evaluation during the project:	
	OMP 3	Project team actively involved in defining the criteria for selecting key suppliers for the development of different elements	Project team actively involved in choosing the actual supplier(s) to be involved	
	OMP 4	Freezing the final degree of supplier development responsibility in the project when the supplier has been chosen	Project team actively involved in planning in which project phase the suppliers' development activities must start	
	OMP 5	Project team actively involved in determining upfront the specific operational performance targets with the supplier	Project team actively involved in defining upfront the actual supplier development activities (e.g.proto-typing, tooling, testing) with the supplier in a project agreement	Project team actively involved in specifiying contractual conditions regarding the collaboration in a formal contract.
	OMP 6	Project team actively involved in determining upfront the communication structure between project team and individual first tier suppliers	Project team actively involved in determining upfront the communication structure between the first tier suppliers and their subsuppliers	Project team actively involved in determining upfront the communication structure between different first tier suppliers
	OMP 7	Project team actively involved in coordinating supplier develoment activities between the project team and individual first tier suppliers	Project team actively involved in coordinating supplier develoment activities between the first tier suppliers and their subsuppliers	Project team actively involved in coordinating supplier develoment activities between different first tier suppliers
	OMP 8	Project team actively involved in evaluating supplier designs regarding commercial aspects (e.g., component availability, lead-time costs).	Project team actively involved in evaluating supplier designs regarding technical aspects (e.g., quality, manufacturability, serviceability).	Project team actively involved in investigating possibilities for standardization of elements of the final product.4.
	OMP 9	Project team actively involved in reviewing how suppliers performed in this development project.	Project team actively involved in feeding forward suppliers' development performance to be included in the preferred supplier list for future supplier selection.	

Appendix 7.1c Enabling conditions

Element	Variable	Items (questions)	Items (questions)	Items (questions)	Items (questions)
Business Unit Enablers	**Cross-functional Orientation R&D-Purchasing Organisation (CFO)**	the technical expertise in the Purchasing department matches the way expertise in your R&D/Engineering department is organized.	you have assigned buyers with separate responsibilities, those with initial (tactical) responsibilities, (e.g. supplier selection in development projects) and with operational responsibilities (e.g. ordering).		
	Human Resource Qualities				
	Experience-organisation	job-rotation of Purchasing employees to other departments is common practice.	job-rotation of R&D employees to other departments is common practice.		
	Educational level	the majority of the Purchasing employees have a higher educational degree.	the majority of the R&D employees have a higher educational degree.		
	Proactiveness Purchasing and R&D organisation	the majority of the Purchasing employees are proactive in approaching *R&D people* by offering help without being specifically asked.	The majority of the R&D employees are proactive in approaching *Purchasing people* by offering help without being specifically asked.		
Project Team Enablers	**Cross-functional orientation R&D-Purchasing project team (CFT)**	representatives from the Purchasing department were involved from the beginning.	representatives from the Purchasing department were involved extensively.		
	Development Team Stability (DTS)	the same buyers stayed on the project team as long as their involvement was necessary.	the same R&D members stayed on the project team as long as their involvement was necessary.		
	Educational level team	The majority of the project team members from the Purchasing department had at least a higher educational degree.	The majority of the project team members from the R&D /Engineering department had at least a higher educational degree.		

Enabling conditions continued

Element	Variable	Items (questions)	Items (questions)	Items (questions)	Items (questions)
	Experience-team	The majority of the project team members from the Purchasing department had been working before in other company departments.	The majority of the project team members from the R&D/Engineering department had been working before in other company departments.	The majority of the project team members from the Purchasing department had a sufficient technical understanding of the elements of the final product. (e.g., components, modules)	The majority of the project team members from the R&D/Engineering department had sufficient commercial skills when designing the elements of the final product. (value analysis etc)
	Credibility-team	The majority of the project team members from the Purchasing department accepted suggestions from engineers on technical aspects of the elements of the final product. (e.g., components, modules)	The majority of the project team members from the R&D/Engineering department accepted suggestions from purchasers on commercial aspects of the elements of the final product. (e.g., components, modules)		
Collabortion enablers	**Supplier Technical Capabilities**	Satisfaction with the technical capabilities the suppliers brought into the project?	Extent to which suppliers thoroughly understood our product requirements.		
	Supplier Project Management Capabilities	Satisfaction with the project management skills the suppliers used in the project? (e.g., planning the project and coordinating activities between departments)	thoroughly understood your project planning requirements (timing, volume requirements).		
	Supplier Target Cost capabilities	Extent to which suppliers thoroughly understood our commercial project requirements	Supplier contribution to meeting the commercial targets of the project (e.g. cost price)		
	Relevant past experience	Share of new suppliers	Share of suppliers involved in one previous project	Share of suppliers involved in multiple projects	Share of suppliers that have assumed a greater development responsibility
	Compatibility in culture and operating style and	The supplier's organisation and way of working fitted well with our organisation			
	Mutual trust	The supplier provided all the information we needed	We provided the supplier with all the information they needed		

Appendix 7.1d Driving conditions

	Variable	Items (questions)	Items (questions)	Items (questions)	Items (questions)
Business Unit Drivers	**Busines Unit Size (BUS)**	Total Revenues for Business Unit in 2001	Nr of employees for Business Unit in 2001		
	Supplier Dependence (SDE)	Purchased value in 2001	Total Revenues for Business Unit in 2001		
	Manu-facturing Type	Unit/small series production	Project based production	Series production/ mass assembly production	Process production
	R&D dependence (RDE)	R&D expenditure as a percentage of total revenues in 2001 for this business unit.			
Project Drivers	**Project Complexity/ Size (PSI)**	Available R&D budget at the start of the project:	Average number of people on the project team:	Actual development lead-time of this project.	
	Degree of project innovation	How new were the elements of the final product at the start of the project as perceived by the project team?	How new was the final product configuration at the start of the project as perceived by the project team?	How new were the product technologies of the final product at the start of the project as perceived by the project team?	How new were the manufacturing technologies of the final product at the start of the project as perceived by the project team?
Collaboration Drivers	**Part Developmen t Complexity**				
	Part Developmen t Novelty				
	Part Techno-logical uncertainty				
	Part's Contribution to overall product functionality				

Appendix 7.2 Survey questionnaires case studies

(DAP/PAN/BE /HJH)

A Instructions Survey : Strategic Management supplier involvement

Instructions Survey

Dear participant,

Thank you in advance for participating in this research project! By answering this questionnaire you contribute to a series of case studies on the successful management practices and conditions for using suppliers as a source of competitive advantage in product development.
We assure you that all information will be treated confidentially and cannot be traced back to any individual respondent or company.

Structure questionnaire

Part A contains questions regarding characteristics of your Business Unit.
Part B contains questions regarding characteristics and performance of the selected development project.
Part C contains questions regarding the specific activities, preparing and supporting the involvement of suppliers in specific development projects.
Part D contains questions regarding the organisation and capabilities of the purchasing /R&D department and supplier firm.
Part E contains questions regarding your professional background.

Important Notes

- Answering the questions will take approximately twenty minutes.
- If some of the terms used in the questionnaire are unclear, we invite you to read the definitions below.

Definitions

1. **Building Blocks:** those elements of the final product configuration that may appear as subsystems, modules, subassemblies, major components, etc in the final product.
2. **Building Block Technical Performance:** the functional performance, conformance to specifications, the reliability and durability of the building block developed together with your suppliers.
3. **Building Block Cost:** the cost or contract price of the building block developed, assembled and/or manufactured by your supplier(s).
4. **Building Block** include costs (e.g. engineering hours) related to internal
5. **Development Costs:** development and engineering activities regarding those building blocks mainly developed by suppliers. This also encompasses any development expenses by suppliers as far as your firm pays them for.
6. **Building Block Development Time:** the time between the first moment of supplier involvement to the moment of building block release.
7. **Product Configuration:** the way the building blocks are linked together is the product configuration also called product architecture or systems design.
8. **Technology Roadmap:** The time and investment path indicating when specific technologies with specific performance levels become available in your company or in the supplier market or at the competition.

Thank you very much for your co-operation

Part A. Business Unit Characteristics

Please provide the following information regarding your business unit;

1. Total revenues for this business unit in 2001: ______________________________ millions of €.
2. Total number of employees for this business unit in 2001:_____________________employees.
3. R&D expenditure as a percentage of total revenues in 2001 for this business unit: _________%.
4. Purchasing turnover in your Business Unit in 2001: _____________________________ employees.
5. Please indicate the nature of your main manufacturing operations (tick one option):
   O unit/small series production (e.g. components)
   O series based production (e.g. complex assemblies)
   O project based production (e.g. construction project)
   O mass assembly (e.g. consumer electronics or cars assembly)
   O process production (e.g. chemicals)
   O other (government, mining, ...)

6. Please indicate in which industry your Business Unit's main activities are:

   ____

Part B. Project Characteristics

In the next set of questions, we focus on some specific characteristics of the project you selected beforehand.

Please indicate the relative importance of the project performance objectives (please tick the appropriate box):	Not important at all 0	1	2	3	4	Neither unimportant nor important 5	6	7	8	9	Very impor-tant 10	Do not know
7. Final Product Tech-nical Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8. Final Product Cost	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9. Development Cost	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10. Time-to- market	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Compared to the target set at the beginning, how did the selected project (i.e. the final product) perform in terms of (please tick the appropriate box):	A lot worse than target 1	2	3	Exactly on target 4	5	6	Much better than target 7	Do not know
11. Final Product Technical Performance	☐	☐	☐	☐	☐	☐	☐	☐
12. Final Product Cost	☐	☐	☐	☐	☐	☐	☐	☐
13. Development Costs	☐	☐	☐	☐	☐	☐	☐	☐
14. Time-to-market	☐	☐	☐	☐	☐	☐	☐	☐

In this section, we would like to ask you about the development performance of the collaboration with all suppliers involved in the selected project. Performance indicators are Building block Technical Performance, Building block Cost, Building block Development Costs and Building block Development Time.

Please indicate for each of the performance indicators the respective percentages of the total number of suppliers involved that have performed *worse*, *better than* or *on target.*

Building Block Performance targets ↓	% of suppliers performing *worse than target*	% of suppliers performing *on target*	% of suppliers performing *better than target*	Total should be:
15. Technical performance	%	%	%	100%
16. Cost	%	%	%	100%
17. Development Costs	%	%	%	100%
18. Development Time	%	%	%	100%

Please indicate the respective percentages of the total number of suppliers involved that have performed *worse*, *the same, better than* the performance of *similar building blocks in previous projects*.

Building Block Performance targets ↓	*worse than* the performance of the Building Blocks in previous projects	*the same* compared to the performance of Building Blocks in previous projects	*better than* the performance of Building Blocks in previous projects	Total should be:
19. Technical performance	%	%	%	100%
20. Cost	%	%	%	100%
21. Development Costs	%	%	%	100%
22. Development Time	%	%	%	100%

Please indicate to what extent you judge the collaboration with the suppliers involved in the project *will result* or *has* resulted in the following long-term benefits (please tick the appropriate box):	Completely disagree 1	2	3	Neither disagree nor agree 4	5	6	Comple-tely agree 7	Do not know
23. better alignment of technology roadmaps of your suppliers and your business unit.	☐	☐	☐	☐	☐	☐	☐	☐
24. improved access for your firm to suppliers' knowledge.	☐	☐	☐	☐	☐	☐	☐	☐
25. faster development speed in future collaboration with suppliers	☐	☐	☐	☐	☐	☐	☐	☐
26. lower development costs in future collaboration with these suppliers	☐	☐	☐	☐	☐	☐	☐	☐
27. better performing building block designs (e.g. higher value-price ratio)	☐	☐	☐	☐	☐	☐	☐	☐
28. lower Building Block cost (e.g. lower life cycle through better serviceability)	☐	☐	☐	☐	☐	☐	☐	☐

Part C. Strategic Management of Supplier involvement in product development

In this series of questions we ask you to make observations regarding specific activities and processes that are carried out to prepare and organise supplier involvement in future development projects. These activities are assumed to take place outside (not triggered by) one specific development project!

When answering the following questions:

1. please only think of the period before the project started;
2. please bear in mind that some activities can also be carried out outside the purchasing department (e.g. by the R&D department);
3. please bear in mind that the strategic management of suppliers can take place both in an informal and formal way

Prior to the start of the selected project, our Business Unit has been actively: ➔	Strongly disagree 1	2	3	Neither disagree, nor agree 4	5	6	Strongly agree 7	Do not know
29. formulating guidelines for internal departments on how to manage supplier involvement in the product development process (e.g. supplier selection, project agreement format).	☐	☐	☐	☐	☐	☐	☐	☐
30. formulating guidelines for *external suppliers* on how to collaborate with your business unit in the product development process (design standards, organisational structure).	☐	☐	☐	☐	☐	☐	☐	☐
31. communicating the guidelines to *internal departments* on how to manage supplier involvement in the product development process.	☐	☐	☐	☐	☐	☐	☐	☐
32. communicating the guidelines to *external suppliers* on how to collaborate with your business unit in the product development process.	☐	☐	☐	☐	☐	☐	☐	☐
33. determining which *technology development* activities to outsource to suppliers.	☐	☐	☐	☐	☐	☐	☐	☐
34. determining which *product development activities* to outsource to suppliers.	☐	☐	☐	☐	☐	☐	☐	☐
35. scanning supplier markets for competitive developments (e.g. new entrants, regulations etc.).	☐	☐	☐	☐	☐	☐	☐	☐
36. scanning supplier markets for emergence of alternative technologies.	☐	☐	☐	☐	☐	☐	☐	☐
37. scanning individual suppliers currently in your supply base for specific developments (e.g. technical, commercial and ownership developments).	☐	☐	☐	☐	☐	☐	☐	☐

Prior to the start of the selected project, our Business Unit has been actively: ➔	Strongly disagree 1	2	3	Neither disagree, nor agree 4	5	6	Strongly agree 7	Do not know
38. pre-qualifying suppliers for addition to your Approved Supplier List.	☐	☐	☐	☐	☐	☐	☐	☐
39. evaluating innovation-related capabilities of suppliers (e.g. supplier engineering capabilities, investment by supplier in own R&D).	☐	☐	☐	☐	☐	☐	☐	☐
40. involving suppliers in technology development activities for application in future product development projects.	☐	☐	☐	☐	☐	☐	☐	☐

41.	applying technical standards being developed in the supplier market when designing new products.	☐	☐	☐	☐	☐	☐	☐	☐
42.	using <u>building blocks</u> already available in the supplier market when designing new products.	☐	☐	☐	☐	☐	☐	☐	☐
43.	taking future supplier capabilities as a starting point in developing the Business Unit's technology roadmap.	☐	☐	☐	☐	☐	☐	☐	☐
44.	Influencing suppliers to focus their resources on specific technological areas, bringing this in line with your Business Unit's technology roadmap.	☐	☐	☐	☐	☐	☐	☐	☐
45.	influencing suppliers to develop specific building blocks, bringing this in line with your Business Unit's product roadmap.	☐	☐	☐	☐	☐	☐	☐	☐
46.	reviewing guidelines for *internal departments* on how to manage supplier involvement in the product development process.	☐	☐	☐	☐	☐	☐	☐	☐
47.	reviewing guidelines for *external suppliers* on how to collaborate with your Business Unit in the product development process.	☐	☐	☐	☐	☐	☐	☐	☐

Part D. Purchasing/R&D Organisation and Capabilities

Please indicate the extent to which you agree with the following statements (please tick the appropriate box):

	In your organisation:	Strongly disagree 1	2	3	Neither disagree, nor agree 4	5	6	Strongly agree 7	Do not know
48.	the technical expertise in the Purchasing department matches the way expertise in your R&D/Engineering department is organised. (e.g. specialised around product technologies)	☐	☐	☐	☐	☐	☐	☐	☐
49.	there are buyers with specific *operational* (e.g. ordering) *buying responsibilities* and with *initial* (e.g. supplier selection) buying responsibilities.	☐	☐	☐	☐	☐	☐	☐	☐
50.	the purchasing department is formally represented in the project team.	☐	☐	☐	☐	☐	☐	☐	☐
51.	technical experience gained in previous jobs is an important selection criterion for Purchasers to be employed in your organisation.	☐	☐	☐	☐	☐	☐	☐	☐
52.	commercial skills (e.g. value analysis and value engineering;) developed in previous jobs is an important selection criterion for R&D employees to be employed in your organisation.	☐	☐	☐	☐	☐	☐	☐	☐
53.	job-rotation of *Purchasing employees* to other departments is common practice.	☐	☐	☐	☐	☐	☐	☐	☐
54.	job-rotation of *R&D employees* to other departments is common practice.	☐	☐	☐	☐	☐	☐	☐	☐
55.	the majority of the *Purchasing employees* have a higher educational degree.	☐	☐	☐	☐	☐	☐	☐	☐
56.	the majority of the *R&D employees* have a higher educational degree.	☐	☐	☐	☐	☐	☐	☐	☐
57.	the majority of the *Purchasing employees* are proactive in approaching R&D people by offering help without being specifically asked.	☐	☐	☐	☐	☐	☐	☐	☐
58.	the majority of the *R&D employees* are proactive in approaching Purchasing people by offering help without being specifically asked.	☐	☐	☐	☐	☐	☐	☐	☐

Part E. Respondent Profile

Please provide the following professional background information:

- Name: ______________________________
- Position: ______________________________
- Number of years working in the R&D/Purchasing area: ______________________________
- Number of years working in this company: ______________________________

B. Instructions Questionnaire: Operational Management supplier involvement

Dear participant,

Thank you in advance for participating in this research project! By answering this questionnaire you contribute to a series of case studies on the successful management practices and conditions for using suppliers as a source of competitive advantage in product development.
We assure you that all information will be treated confidentially and cannot be traced back to any individual respondent or company.

Structure questionnaire

Part A contains questions regarding some characteristics and performance of the selected project.
Part B contains questions regarding the specific activities the project team carried out to work together with suppliers in product development.
Part C contains questions regarding the organisation/capabilities and experience of both customer and suppliers.
Part D contains questions regarding your professional background.

Important Notes

- Answering the questions will take approximately twenty minutes.
- If some of the terms used in the questionnaire are unclear, we invite you to read the definitions below.

Definitions

1. **Building Blocks:** those elements of the final product configuration that may appear as subsystems, modules, subassemblies, major components, etc in the final product.
2. **Building Block Technical Performance:** the functional performance, conformance to specifications, the reliability and durability of the Building block developed together with your suppliers.
3. **Building Block Cost:** the cost or contract price of the building block developed, assembled and/or manufactured by your supplier(s).
4. **Building Block Development Costs:** include costs related to internal development and engineering activities regarding those building blocks mainly developed by suppliers. This also includes any development expenses by suppliers as far as they are paid for by your firm.
5. **Building Block Development Time:** the time between the first moment of supplier involvement to the moment of building block release.
6. **Product configuration:** the way the building blocks are linked together is the product configuration also called product architecture or systems design.
7. **Market introduction:** the moment of first customer shipment.

8.	**Project start:**	the moment on which the formal project go-ahead has been given by approving the project definition.
9.	**Purchase value**	the purchase value is the total amount paid to all suppliers delivering building blocks/services for the selected product).
10.	**Supplier development responsibility:**	refers to the level of specifications at which the supplier's contribution in the project starts (e.g. off-the-shelf, detailed-controlled, grey box or black box specifications). The categories are ordered from a low level to higher levels of responsibility.
11.	**Supplier development activities:**	those activities that typically need to be carried out for the design, engineering and preparation for production regarding the building block (E.g. CAD drawing, prototyping, testing, tooling development etc).

Part A. Project Characteristics

In the next set of questions, we focus on some specific characteristics of the project you selected beforehand.

1. Please indicate the available budget at the start of the project:________________________€.
2. Please indicate the number of persons working on the project team:______Project team members.
3. Please indicate actual development time used in this project (time between project start and first customer shipment):

☐	☐	☐	☐	☐	☐	☐
< 0,5 year	0,5-1 year	1-2 years	2-3 years	3-4 years	4-5 years	>5 years

Please indicate the relative importance of the project performance objectives at the beginning of the project.	Not important at all 0	1	2	3	4	Neither unimportant nor important 5	6	7	8	9	Very impor-tant 10	Do not know
4. Final Product Tech-nical Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. Final Product Cost	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. Development Cost	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. Time-to- market	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Compared to the target set at the beginning, how did the selected project (i.e. the final product) perform in terms of (please tick the appropriate box):	A lot worse than target 1	2	3	Exactly on target 4	5	6	Much better than target 7	Do not know
8. Final Product Technical Performance	☐	☐	☐	☐	☐	☐	☐	☐
9. Final Product Cost	☐	☐	☐	☐	☐	☐	☐	☐
10. Development Costs	☐	☐	☐	☐	☐	☐	☐	☐
11. Time-to-market	☐	☐	☐	☐	☐	☐	☐	☐

12. Please describe what events have impacted on the reported project performance.

Compared to the target set at the beginning, how did the selected project (the total final product) perform in terms of:	A lot worse than target 1	2	3	Exactly on target 4	5	6	Much better than target 7	Do not know
13. sales volume	☐	☐	☐	☐	☐	☐	☐	☐
14. market share	☐	☐	☐	☐	☐	☐	☐	☐
15. profitability	☐	☐	☐	☐	☐	☐	☐	☐

The following questions deal with the newness of various aspects of the final product as perceived by the project team, at the start of the project. (Please tick the appropriate box.)

Concerning the final product for your company, how <u>new</u> were the following elements:	Not new at all 1	2	3	Some-what new 4	5	6	Comple-tely new 7	Do not know
16. the building blocks?	☐	☐	☐	☐	☐	☐	☐	☐
17. the product configuration?	☐	☐	☐	☐	☐	☐	☐	☐
18. the product technologies?	☐	☐	☐	☐	☐	☐	☐	☐
19. the manufacturing technologies?	☐	☐	☐	☐	☐	☐	☐	☐

20. Please indicate the relative share of the purchase value of all building blocks in the product cost price at market introduction. (Please tick the appropriate box.)

☐	☐	☐	☐	☐
0-20%	20%-40%	40% -60%	60%-80%	80-100%

21. Please indicate the relative share of the suppliers' *engineering hours* in the total engineering hours invested in the selected project. (Please tick the appropriate box.)

☐	☐	☐	☐	☐
0-20%	20%-40%	40% -60%	60%-80%	80-100%

In the next section, we ask you for the total value of purchased parts of the final product. We would like to understand how this value is distributed across different categories of parts. Each category refers to a specific distribution of tasks and responsibilities between the supplier and the development team regarding the development of the part.

22. For each category of parts, please indicate the proportion of the total purchasing value it represents.

Part categories	**% of total Purchasing value**
Supplier proprietary parts/Off-the shelf components Catalogue or standard components or OEM-products.	%
Detailed-controlled parts On the basis of a detailed design the supplier is given responsibility for setting up his production and assembly process and for ultimate production and assembly. Here possible input from suppliers is *limited* to discussing production engineering (e.g. makeability tolerances) aspects.	%
Grey box parts On the basis of functional specifications and a basic design of a building block the supplier is	%

given responsibility for: the detailed design; construction and testing of a detailed design; and the setting up of production and assembly processes.	
Black box-parts On the basis of the functional specifications and interface details of a building block the supplier is given responsibility for: the basic design (concept and feasibility studies); the detailed design; testing of the (global and detailed) design of the building block; and possibly setting up of production and assembly processes.	%

Total Purchasing value = 100%

Please indicate the *relative influence* of the project team versus the suppliers on,	Almost all project team 1	2	3	Equally project team and supplier 4	5	6	Almost all supplier 7	Do not know
23. product design decisions for setting original specifications.	☐	☐	☐	☐	☐	☐	☐	☐
24. product design decisions for the first prototype.	☐	☐	☐	☐	☐	☐	☐	☐

Please indicate the extent to which the project team,	To a very low extent 1	2	3	To some extent 4	5	6	To a very high extent 7	Do not know
25. defined detailed specifications	☐	☐	☐	☐	☐	☐	☐	☐
26. specified manufacturing tolerances	☐	☐	☐	☐	☐	☐	☐	☐

In this section, we would like to ask you about the development performance of the collaboration with all suppliers involved in the selected project. Performance indicators are Building block Technical Performance, Building block Cost, Building block Development Costs and Building block Development Time.
Please indicate for each of the performance indicators the respective percentages of the total number of suppliers involved that have performed *worse*, *better than* or *on target*.

Building Block Performance targets ↓	% of suppliers performing *worse than target*	% of suppliers performing *on target*	% of suppliers performing *better than target*	Total should be
27. Technical performance	%	%	%	100%
28. Cost	%	%	%	100%
29. Development Costs	%	%	%	100%
30. Development Time	%	%	%	100%

Please indicate the respective percentages of the total number of suppliers involved that have performed *worse*, *the same, better than* compared to the performance of *similar building blocks in previous projects*.

Building Block Performance targets ↓	*Worse than* the performance of the Building Blocks in previous projects	*The same* compared to the performance of Building Blocks in previous projects	*Better than* the performance of Building Blocks in previous projects	Total should be
31. Technical performance	%	%	%	100%
32. Cost	%	%	%	100%
33. Development Costs	%	%	%	100%
34. Development Time	%	%	%	100%

	Completely dissatisfied			Neither dissatisfied nor satisfied			Com-pletely satisfied	Do not know
35. To what extent were you satisfied with the technical capabilities the suppliers brought into the project?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
36. To what extent were you satisfied with the project management skills the suppliers used in the project. (For example, planning the project and co-ordinating activities between departments)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

Please indicate the extent to which suppliers in the selected project have collaborated in *previous* projects.

% of total suppliers involved in the selected project

37. New suppliers ____________ %

38. Suppliers involved in one previous project ____________ %

39. Suppliers involved in multiple projects ____________ %

Total 100%

Please indicate the extent to which the level of supplier development responsibility differed in the collaboration compared to the *previous* project. (Supplier proprietary parts/Off-the shelf components, Detailed-controlled parts, Grey box parts, Black box-parts). The aforementioned categories are ordered from a low level to higher levels of responsibility.

% of total suppliers involved in the selected project

40. Suppliers that have been involved on a lower level in the previous project ____________ %

41. Suppliers that have been involved on the same level in the previous project ____________ %

42. Suppliers that have been involved on a higher in the previous project ____________ %

Total 100%

Part B. Management of Supplier Involvement in the selected project

In the next series of questions, we ask you to make observations regarding specific activities and processes to work with suppliers in the selected project! These activities and processes could be carried out by the project team members. Please indicate to what extent you agree with the following statements. (Please tick the appropriate box.)

In the selected project, the *project team* has been actively involved in: ➔	Strongly dis-agree 1	2	3	Neither disagree nor agree 4	5	6	Strongly agree 7	Do not know
43. identifying upfront the different building blocks of the final product for which development activities were planned to be outsourced to external suppliers.	☐	☐	☐	☐	☐	☐	☐	☐
44. defining the *preferred* supplier development responsibility regarding the various building blocks of the final product (before the supplier is chosen).	☐	☐	☐	☐	☐	☐	☐	☐
45. collecting suggestions from suppliers on alternative technologies or components during the product development process.	☐	☐	☐	☐	☐	☐	☐	☐
46. comparing alternative suppliers and their technologies or components for further evaluation during the project.	☐	☐	☐	☐	☐	☐	☐	☐

47. defining the criteria for selecting key suppliers for the development of different building blocks.	☐	☐	☐	☐	☐	☐	☐	☐
48. choosing the actual supplier(s) to be involved.	☐	☐	☐	☐	☐	☐	☐	☐
49. freezing the final degree of supplier development responsibility when the supplier has been chosen.	☐	☐	☐	☐	☐	☐	☐	☐
50. planning in which project phase the development activities of different suppliers must start.	☐	☐	☐	☐	☐	☐	☐	☐
51. defining upfront the *actual* supplier development activities (e.g. prototyping, tooling, testing) with the supplier in a project agreement.	☐	☐	☐	☐	☐	☐	☐	☐
52. determining upfront the specific operational performance targets with the supplier (e.g. building block quality target, cost target etc.).	☐	☐	☐	☐	☐	☐	☐	☐
53. specifying contractual conditions regarding the collaboration in a formal contract (e.g. ownership of knowledge jointly developed, etc.).	☐	☐	☐	☐	☐	☐	☐	☐
determining upfront the communication structure between								
54. the project team and individual first tier suppliers	☐	☐	☐	☐	☐	☐	☐	☐
55. the first tier suppliers and their sub-suppliers	☐	☐	☐	☐	☐	☐	☐	☐
56. the different first tier suppliers (of subsystems/parts that have interaction/interfaces)	☐	☐	☐	☐	☐	☐	☐	☐

In the selected project, the *project team* has been actively involved in: ➔	Strongly disagree 1	2	3	Neither disagree nor agree 4	5	6	Strongly agree 7	Do not know
co-ordinating the actual development activities between								
57. the project team and individual first tier suppliers	☐	☐	☐	☐	☐	☐	☐	☐
58. the first tier suppliers and their sub-suppliers	☐	☐	☐	☐	☐	☐	☐	☐
59. the different first tier suppliers (of subsystems/parts that have interaction/interfaces)	☐	☐	☐	☐	☐	☐	☐	☐
60. evaluating suppliers' building block designs regarding commercial aspects (e.g. component availability, lead-time, and costs).	☐	☐	☐	☐	☐	☐	☐	☐
61. evaluating suppliers' building block designs regarding technical aspects (e.g. quality, makeability, and serviceability).	☐	☐	☐	☐	☐	☐	☐	☐
62. investigating possibilities for standardisation of building blocks.	☐	☐	☐	☐	☐	☐	☐	☐
63. investigating possibilities for simplification of building block designs.	☐	☐	☐	☐	☐	☐	☐	☐
64. reviewing how suppliers performed in this development project.	☐	☐	☐	☐	☐	☐	☐	☐
65. feeding forward suppliers' development performance to be included in the preferred supplier list for future supplier selection.	☐	☐	☐	☐	☐	☐	☐	☐

Part C. Organisation/Capabilities and Experience

In this section, the questions address the organisation, the capabilities and available experience of the Purchasing, R&D/engineering department and of the suppliers involved in the selected project. (Please tick the appropriate box.) Please indicate the extent to which you agree with the following statements:

In the project team, ↓	Strongly dis-agree 1	2	3	Neither disagree nor agree 4	5	6	Strongly agree 7	Do not know
66. representatives from the Purchasing department have been involved *from the very beginning*.	☐	☐	☐	☐	☐	☐	☐	☐
67. representatives from the Purchasing department have been involved *extensively* in the selected project.	☐	☐	☐	☐	☐	☐	☐	☐
68. the same buyers have stayed on the project team as long as their involvement was necessary	☐	☐	☐	☐	☐	☐	☐	☐
69. the same R&D members have stayed on the project team as long as their involvement was necessary.	☐	☐	☐	☐	☐	☐	☐	☐

The majority of the project team members from the Purchasing department, ↓	Strongly dis-agree 1	2	3	Neither disagree nor agree 4	5	6	Strongly agree 7	Do not know
70. have been working before in other company departments.	☐	☐	☐	☐	☐	☐	☐	☐
71. have a sufficient technical understanding of the building blocks of the final product	☐	☐	☐	☐	☐	☐	☐	☐
72. accepted suggestions from engineers on commercial aspects of the building blocks involved.	☐	☐	☐	☐	☐	☐	☐	☐

The majority of the project team members from the <u>R&D/Engineering department</u>, ↓	Strongly dis-agree 1	2	3	Neither disagree nor agree 4	5	6	Strongly agree 7	Do not know
73. have been working before in other company departments.	☐	☐	☐	☐	☐	☐	☐	☐
74. have at least a higher educational degree	☐	☐	☐	☐	☐	☐	☐	☐
75. have sufficient commercial skills (e.g. use value analysis) when designing the building blocks used in the final product.	☐	☐	☐	☐	☐	☐	☐	☐
76. accepted suggestions from purchasers on technical aspects of the building blocks involved.	☐	☐	☐	☐	☐	☐	☐	☐

The suppliers in this project, ↓	Strongly dis-agree 1	2	3	Neither disagree nor agree 4	5	6	Strongly agree 7	Do not know
77. thoroughly understood our product requirements.	☐	☐	☐	☐	☐	☐	☐	☐
78. had the necessary skills to plan, to monitor and to co-ordinate development activities.	☐	☐	☐	☐	☐	☐	☐	☐

Part D. Respondent Profile

Please provide the following professional background information.

- Name: ____________________
- Position: ____________________
- Number of years working in R&D/Engineering area: ____________________
- Number of years working in this company: ____________________

Thank you very much for completing the questionnaire

Appendix 7.3 Interview questionnaires cross-sectional case studies

A. General questions

1. What is your function within this company?
2. In what way were you involved in this project/ what was your role in this project?
3. What were your responsibilities during this project?
4. Which activities did you perform in the light of this project?
5. What were the reasons for <company name> to involve this supplier in the project?
6. Are you content with the result of the project (in terms of the final product)? Why/why not?
7. Has the involvement of the supplier influenced the project result? If yes, in what way(s)?
8. Are you content with the building block the supplier provided (in terms of the module the supplier supplied)? Why/why not?
9. Are you content with the collaboration with this supplier in this project? Why/why not?
10. Can you think of any factors that might have influenced the course of the project, but that were beyond your control? If yes, can you name some factors? To what extent and in what ways have these factors influenced the project result?
11. Do you think that your understanding of your supplier's knowledge knowledge and skills has improved during this project? If yes, why do you think so?
12. Has <company name> had any learning experiences with this supplier in this project? If yes, can you give an example?

B. Managerial Processes

Strategic Management Processes

13. Does <company name> have guidelines for the internal departments on how to involve suppliers in product development?
14. Are these guidelines communicated?
15. Have these guidelines been followed during this project?
16. Does <company name> have guidelines for external suppliers on how they are supposed to collaborate with <company name>?
17. Are these guidelines communicated?
18. Have these guidelines been followed during this project?
19. Have you ever been forced to abandon your guidelines during a project or before a project has started? If yes, can you give an example? How did you cope with that situation? Can you judge how often this occurred?
20. Does <company name> have a policy with regard to what products or processes are core and non-core?

21. Has that policy been documented?
22. Who were involved in forming that policy?
23. Does <company name> operate in correspondence to that policy?
24. Do you inform yourself of new developments in the supplier market?
25. Can you give examples of methods you use to do that?
26. Do you perform risk-analyses with regard to new products or technologies?
27. What methods do you use to do that?
28. Do you ever ask a supplier to develop a solution for a problem that does not exist yet/a future problem?
29. Does <company name> have a list of preferred suppliers?
30. Were the suppliers in this project chosen from that list? If not, why not? Then, how was this specific supplier found? On what grounds did you choose this supplier?
31. Has it ever happened that you couldn't find a suitable supplier? If so, what do you do then?
32. Is product development initiated by <company name>' R&D department (does <company name> look for a supplier to fit their design) or by what the supplier market has to offer (is <company name>' design based on existing modules, technologies, et cetera)?
33. Did you share technology roadmaps with your supplier in this project?
34. How does <company name> get a supplier to collaborate in new product development? Is there an incentive scheme to do that?
35. How are risks of investment shared between manufacturer and supplier?
36. How are benefits shared between manufacturer and supplier?
37. Did you evaluate the supplier's performance?
38. Do you do that per project or for the whole relationship periodically?
39. What did you evaluate the supplier on?
40. Did you evaluate, in hindsight, if the way the supplier was involved was the right way in the light of this specific project? How do you do that?
41. Do these evaluations result in changes? If so, can you give examples?
42. Do you evaluate guidelines? If so, how do you do that?
43. Do guidelines ever change? Can you judge how often that happens? What causes these changes to occur? Can you clarify that with an example?

<u>Operational Management Processes:</u>

44. How does <company name> determine which elements of a product are outsourced and which elements of a product are developed in-house?
45. How does <company name> determine the extent of supplier responsibility?
46. Do you, in advance of or during the project collect suggestions on alternative technologies or building blocks that might fit well into the product being developed?
47. Which people are involved in that mostly?
48. What do you do with these suggestions?
49. In advance of the choice for one specific supplier, do you compare multiple suppliers and their technology or building block offerings? On what criteria do you compare them?
50. How is determined which supplier is best suited to the project?
51. Which criteria are used for choosing a supplier?
52. Are these criteria fixed for all projects?
53. In which phase of the product development process is the extent of supplier responsibility frozen?
54. How does <company name> determine when a specific supplier will be involved in the product development process?
55. Are the definite extent of supplier responsibility and the timing communicated to the supplier? If so, how is this done?
56. Did you share technology roadmaps with your supplier in this project?
57. Are the actual activities that the supplier must carry out determined before the start of the project? How is this done (e.g. by the manufacturer, by the supplier or by both)?
58. Does <company name> in advance of the project specify operational targets with regard to product performance? How is this done (e.g. by the manufacturer, by the supplier or by both)?
59. Does <company name> in advance of the project specify operational targets with regard to planning and project management? How is this done (e.g. by the manufacturer, by the supplier or by both)?

60. Is the product development project documented/described in a development contract? How are the contents agreed upon?
61. Does de supplier in this project have suppliers of his own?
62. Who is concerned with the communication between <company name>, the supplier and his subsupplier(s)?
63. Are there more suppliers alongside the supplier that's involved in this benchmark research project? Is it necessary to co-ordinate between these different first-tier suppliers? Who is concerned with that?
64. Has <company name> in advance of the project determined a communication structure for:
65. The project team and the first-tier suppliers?
66. The first-tier suppliers and the second-tier suppliers?
67. The different first-tier suppliers?
68. Approximately, how often were these groups communicate (e.g. very frequently, seldom)?
69. What was communicated about?
70. Were there any specific problems in the communication?
71. Are supplier designs evaluated in advance of the project (e.g. supply, throughput time)? Who is mostly concerned with that?
72. Are suppliers evaluated after the project has terminated? On what criteria are they evaluated (e.g. building block performance, collaboration skills)? How is this evaluation carried out?
73. Does the supplier receive feedback about the evaluation? How is this done?
74. Are the results of the evaluation fed back to the list of preferred suppliers? How is this done?

C. Conditions

75. Is purchasing formally involved in the product development process?
76. What's purchasing's contribution to the new product development process?
77. Do manufacturer and supplier exchange design information? If so, how?
78. Does <company name> have some sort of database with information on alternative suppliers?
79. Does <company name> have some sort of database with information on components and markets?
80. Are technical capabilities a condition for a supplier to be involved in new product development at <company name>?
81. Are project management skills a condition for a supplier to be involved in new product development at <company name>?
82. Are innovative capabilities a condition for a supplier to be involved in new product
83. development at <company name>?
84. Are resources in the supplier's network a condition for a supplier to be involved in new
85. product development at <company name>?

Appendix 7.4 Overview of interviews[2] Cross-sectional case studies

Interviewees Philips Domestic Appliances

Project:			Function:
Fragrance for vacuum cleaner	Internal interviews		Project Leader
			Strategic Buyer Floorcare
			Development Manager Floorcare
			Mechanical Engineer
			Project Purchaser
	External interviews	**Supplier L**	Acquisition & Advice
Boiler for Coffee Machine	Internal interviews		Project Purchaser
			Project Leader
			Development Manager Beverages
	Supplier interviews	**Supplier M**	Sales Manager
			Technical Project Leader

Interviewees PANalytical

Project:			Function:
Energy dispersive spectrometer	Internal interviews		Electrical Purchaser
			Electrical Engineer
			Mechanical Engineer
			Project Purchaser
			Initial Purchaser
			Project Purchaser
			Project Leader Software Development
			Software Development Manager
			Project Leader
	External interviews	**Supplier A**	Director Supplier A Benelux
			Delegated Administrator Supplier A
		Supplier B	?
		Supplier C	Head Engineering Department
		Supplier D	Senior Consultant/ Project Manager
			Account Manager
Sample Changer	Internal interviews		Mechanical Engineer
			Project Purchaser
			Electrical Engineer PCB
			Electrical Engineer cables and wiring
			Project Leader
	External interviews	**Supplier E**	Head Automation Department
			Project Leader
Both	Internal interviews		Development Manager
			Purchasing Manager

[2] Note that not all functions represent a separate interview: some interviewees had two functions. In addition to that, some interviews were held with two interviewees at the same time (this was due to preferences of the people interviewed). A total of 45 interviews were held.

Interviewees Boon Edam

Project:		Supplier	Function:
High-speed safety gate	Internal interview		Project Purchaser
			Mechanical Constructor
			Project Leader
	External interviews	Supplier F	Technical Support Engineer
			Area Sales Manager
		Supplier G	Account Manager
			Constructor
High Capacity revoling door	Internal interview		Mechanical Constructor
			Project Leader
	Supplier interviews	Supplier H	Director
			Engineer
		Supplier I	Account Manager
			Engineer
Both	Internal interviews		Purchasing Manager
			R&D Manager

Interviewees HJ Heinz/ Koninklijke de Ruijter

Project:		Supplier	Function:
Ready-to-drink soda in PET	Internal interviews		Marketing/ Project Leader
			Project Purchaser
	External interviews	Supplier J	Technical Support Manager
Fruit-flavoured sprinkles	Internal interviews		Development/ Project Leader
			Project Purchaser
	Supplier interviews	Supplier K	Product Developer
Both	Internal interviews		NPD Manager HJ Heinz Europe
			European Purchasing Manager Co-pack

Appendix 7.5 Development of a diagnosis instrument for management of supplier involvement

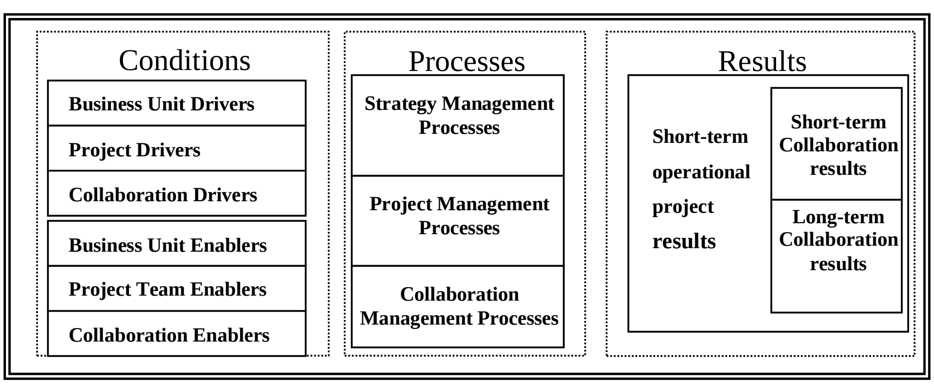
From framework to instrument

This appendix describes the design of the instrument for self-diagnosis. A distinction is made between the object design (the actual instrument) and the realisation design (the steps/ activities carried out to obtain the instrument).

Object design

The objected crystallisation of the instrument is a computer program, which is based on the method of analysis and the adaptations proposed in Chapter 7. Users of the framework are the people who have been involved in the product development project that is diagnosed with the help of the program (e.g. project leader, project purchaser, development manager, purchasing manager, and other relevant functions). The questionnaires developed for the survey and interviews have been used as input for the software program; users can then score the specific items on certain scales. It is important to note that the extent to which a proper diagnosis can be set very much depends on the people actually involved in the project under study. Not all people that were involved in the case studies had all the right information on the relevant parts of the framework (for example: purchasing may be only involved in actual procurement; a project team member may have collaborated with only one supplier out of the four involved in the project, et cetera). In designing the instrument, this is something to be aware of.
Based on the scores assigned by the users, the program calculates results and presents these results in a format that is understandable and usable, preferably by classifying them (e.g. assigning colours). From this classification, problem areas can be derived. Companies themselves should interpret the scores. This results in the following object design:
Figure 7A is used as a starting point for creating the interface with the end-users:

Figure 7A Interface computer program



1. By scoring questions on pre-determined scales, an end-score is calculated for every box in the figure above. This score causes the box to take on a certain colour (red, yellow, and green). Afterwards, end-users can ask for a more detailed overview of the results.

Realisation design

These ideas were transformed using object-oriented programming. To process the data to be entered in the program, the following objects have been defined (according to the logic of the framework):

- Elements (3 groups of drivers; 3 groups of enablers; Strategic Management Processes; etc.);
- Variables (product quality; formulating and communicating guidelines for IPDS; et cetera);
- Items (e.g. questions, for example: compared to the target set at the beginning of the project, how did the project perform in terms of …?; et cetera).

These objects have the following characteristics and interrelationships has depicted in Figure 7B and 7C.

Element	**Variable**	**Item**
- Name; - Score; - Reference to "Variable".	- Name; - Score; - Reference to "Item"; - Dependence (→ "Variable"); - Reference to next "Item".	- Description; - Score; - Reference to next "Item".

Figure 7B Structure object design

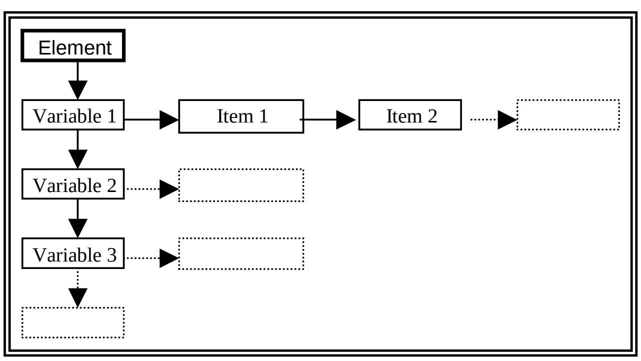


Figure 7C Schematic representation

The score for a specific item is submitted by the end-user. This is an integer on one of the different scales (1 to 3 or 1 to 5). The score of a variable is determined by taking the average of the scores on the different items belonging to that variable. The average score corresponds to a certain colour (Table 7D).

Table 7D Colour attributes

Element	RED	YELLOW	GREEN
Drivers	3	2	1
Enablers	1	2	3
Strategy Management Processes	1,2	3	4,5
Project Management Processes	1,2	3	4,5
Collaboration Management Processes	1,2	3	4,5
Short-Term Collaboration Results	1	2	3
Long-Term Collaboration Results	1	2	3
Short-Term Project Results	1	2	3

The score of an element is determined by an "if, then"-rule: if X variables score value Z or lower, then an element scores for example yellow in stead of green, or red in stead of yellow. If X+Y variables score value Z or lower, then an element scores red in stead of green (and also red in stead of yellow). This way, the end-user will be alerted quickly to low scores. The different elements in the graphical representation will adopt a certain colour, after which the end-user can ask for more specific information on that particular element.

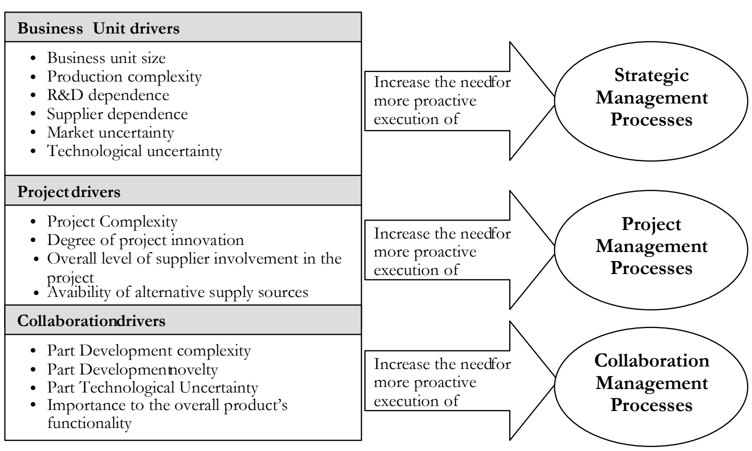
Correcting the scores for (partial) presence drivers

In chapter 7 we concluded that the scores on the processes had to be interpreted taking into account the partial presence of certain driving conditions. Important is that the scores on processes are interpreted against the background of the scores of the drivers. The fact that a certain process scores low may not be problematic because the scores on the drivers and the enablers result in the fact that this particular process is not that critical to project success. On the other hand, we observed that certain processes scored relatively high but may not be good enough. In other words, a low score (2) on coordinating development activities with suppliers does not have to turn red but yellow as a result of a low value on degree of project complexity and of project innovation. As the scores on the drivers and the enablers represent such high risks, they make systematic and intensive attention to that particular process critical to achieving the project's important targets.

In order to facilitate interpretation of the results, this mechanism needs to be incorporated in the instrument. The colours of processes should therefore change when either one of these facts apply. The end-user will see moderating effects of drivers on processes in the change of the colour of that process (from red to yellow or from yellow to green). The other way round, the end-user will see enhancing effects of drivers on processes in the change of the colour of that process (from red to yellow or from green to yellow). The reason for changing the colours and not of the scores of the processes is that a change in colour is more evident to the end-user (and thus not easily overlooked). The score of the process should not change for the end-user's overview: this way, the score combined with the colour provide the diagnosis. For example: a score of 3 on the processes should normally be accompanied by the colour yellow. If a driver increases the need for that process, this medium score of 3 may not be good enough. The colour should therefore change to red, implying that the absolute performance on that process is okay, but that performance is not good enough in the light of this project. If both the colour and the score would change from {3, yellow} to {2, red}, this would imply that the process was carried out reactively instead of proactively, which is not the case. So, changing both variables ({score, colour}) would distort the information provided by the analysis. Therefore, when presenting the results, only the colour will be corrected for the presence of drivers, while the score remains unchanged[3].

In addition to correcting processes for drivers, project results should be corrected for the priority setting of the project performance objectives (which is to be determined by the people using the instrument). If the score on a project result is medium (score=2) and the objective's priority was low (1 or 2), the medium score may actually be good enough. The project result should then score "high" instead of "medium", therefore changes colour from yellow to green. On the other hand, if the score on a project result is "medium" and the objective's priority is "high", the medium score may actually not be good at all. The project result should then score "low" instead of "medium", and therefore change colour, from yellow to red. In order to determine how the colours of the processes should change based on the drivers present, the relationships between certain drivers and processes have to be identified first. The drivers determine to what extent a management process must be carried out to ensure good performance with regard to supplier and project results. Based on inference from literature and the empirical cases we introduce the following relationships depicted in Figure D.

Figure D Hypothesised relationships between drivers and processes



3 Note that the score should be corrected for the calculations performed by the instrument. If some variables score low without having consequences, the calculation logic would assign the colour red to the corresponding element, while the colour should actually be yellow. Correcting the values would prevent the instrument for alerting the end-user while there is nothing wrong.

The relationships between drivers and processes were determined within these levels. Second, the influence of these relationships on the colours of the processes has to be determined (Table 7E). When a process is influenced by multiple drivers, the average value of these drivers is taken and rounded off (threshold value is *.5). The resulting value is used to determine the influence of the drivers on that particular process.

Table 7E Influence of drivers/ enabler scores on process colours

	Performance score (1-5) colour assignment		
Driver value is:	**RED**	**YELLOW**	**GREEN**
1	1	2	3,4,5
2	1,2	3	4,5
3	1,2,3	4	5
Enabler value is:			
1	1,2,3	4	5
2	1,2	3	4,5
3	1	2	3,4,5

Finally, the Project Performance scores need to be weighted with the priority setting for each objective. The weights correct the colours assigned to the performance score. This results in Table 7F.

Table 7F Influence of Performance objective priority on the colours of assigned to the project performance scores

	Performance score (1-5) colour assignment		
Priority Value is:	**RED**	**YELLOW**	**GREEN**
1	1		2,3
2	1	2	3
3	1	2	3
4	1	2	3
5	1,2		3

Appendix 7.6 Instructions Diagnosis Instrument Supplier Involvement Management-Logic

Welcome to the Supplier Involvement Management Process – Logic!
This instrument enables your company to perform a self-diagnosis of a specific product development project by answering different types of questions related to the topic of supplier involvement in product development.

The instrument distinguishes two types of files:
1. The project file: a file containing the data on the project (*.proj);
2. The member file: a file containing the answers of different people that were involved in the project (*.mem).

<u>Instructions for creating a project file:</u>
- Insert the CD-ROM in disk drive E;
- Open the file "SIMP-L.exe" by double clicking;
- Enter the Supplier Involvement Management Process-Logic by selecting "New project" and clicking "Start";
- A window called "Project settings" pops up in which the characteristics of the project can be defined;
- Enter the project's name;
- Rename "supplier 1" by selecting it and clicking "Edit";
- Add up to five more suppliers by clicking "Add". The supplier's name can be entered by using the edit function;
- Add the names of the people involved in the project by clicking "Add" and using the edit function;
- Save the project file by selecting "Save project as" from the project menu and entering a suitable name. The extension of the project file should be "*.proj";
- The project file can be sent (by email) to all people involved in the project, who can then answer the questions.

<u>Instructions for creating a member file:</u>
- Insert the CD-ROM in disk drive E;
- Save the received project file on the hard disk;
- Open the file "SIMP-L.exe" by double clicking;
- Enter the Supplier Involvement Management Process-Logic by selecting "Open project". Browse to find the correct project file, select it and click "Start". The name of the project file is shown at the bottom of the window (centred);
- Create a member file by selecting "New member file" from the file menu;
- Type your name and select the nature of your role: either strategic (director, manager, et cetera) or operational (project team member). The name of the member file is shown at the bottom of the window (right);
- Based on this selection the instrument presents the questions suitable for the role you fulfilled. These questions are to be found in the boxes that are shown as active (black text) in the interface. For the inactive boxes (grey text) no questions need to be answered;
- Clicking the buttons of the active boxes opens windows with questions. Answer these questions by ticking the appropriate boxes. If you cannot answer a certain question, tick "?";
- For some boxes, the questions have to be answered for every supplier separately. You can switch between suppliers by scrolling through the supplier bar (left bottom side of the

window). This comment applies to: Project Enablers, Relationship Enablers; Collaboration Management Processes, Short-term Supplier Effects and Long-term Supplier Effects;

- After answering all questions, check if all active buttons have assumed the colour "dark blue". Any button that has not adopted this colour contains unanswered questions. Click the button of the incomplete box and answer the unanswered questions;
- If all buttons have assumed the colour "dark blue", save the file by selecting "Save member file as" from the file menu and entering your name and/ or function. The extension of the member file should be "*.mem";
- Answers can be changed by opening the member file. Select "Open member file" from the file menu and browse for the proper file;
- The member file can be sent back to the sender of the project file.

Instructions for merging different member files:

- Insert the CD-ROM in disk drive E;
- Open the file "SIMP-L.exe" by double clicking;
- Enter the Supplier Involvement Management Process-Logic by selecting "Open project". Browse to find the proper project file, select it and click "Start";
- Add the different member files to the project by selecting "Define project" from the project menu. Select the users one by one and select their respective member files by clicking "Select file" and browsing the folder for the appropriate files. After selecting all files, click "OK";
- Select "Merge files" from the project menu. The different member files are merged to one new member file;
- Save the merged file by selecting "Save member file as" from the file menu and entering a suitable file name. The extension of the merged member file should be "*.mem". This file can be sent to other people;
- Print the results of the diagnosis (in plain text) by saving the merged member file with the extension "*.csv". This file can be opened in Microsoft Excel and printed from there.

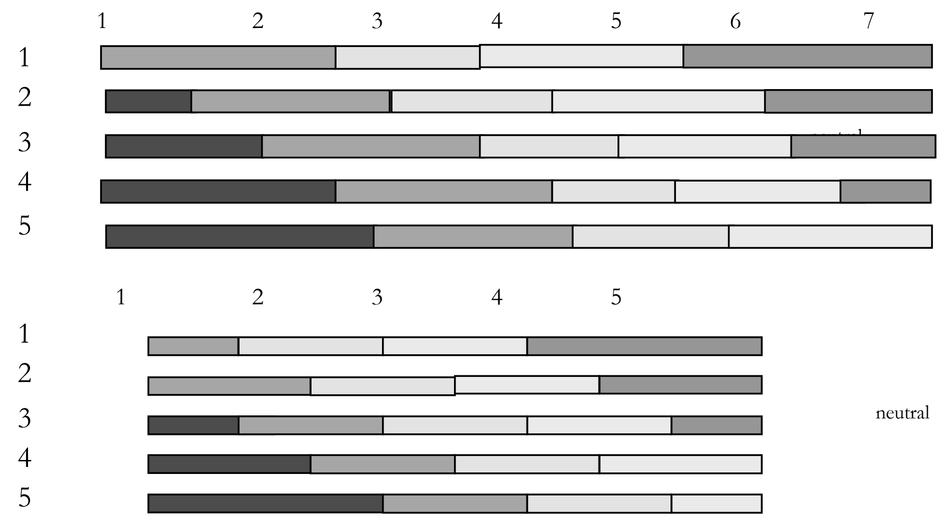
Enabling other people to view the results:

- Insert the CD-ROM in disk drive E;
- Open the file "SIMP-L.exe" by double clicking;
- Enter the Supplier Involvement Management Process-Logic by selecting "Open project". Browse to find the proper merged member file, select it and click "Start". The results of the project can now be viewed;
- De Eindhoven University of Technology would appreciate it very much to obtain the results of your diagnosis. By collecting diagnoses from many different companies in all kinds of industries, a database can be built from which, in the longer run, patterns and relationships between inputs, throughputs and outputs can be derived. This would be most useful, if we could also obtain some more quantitative information on your business unit and the project under study.

  *If you are willing to return the results to the university, please send the merged member file to f.e.a.v.echtelt@tm.tue.nl. Additional quantitative information can be provided by answering the questions of appendix 1 (*Quantitative project data.doc*). The word-document can be saved under the appropriate project name and returned to the university through the above mentioned email address.*

Analysing the results:

The merged member file shows the average scores and standard deviations for all elements of the IPDS framework along with their respective colours. The colours have been assigned to the scores as follows:



The average score is the starting point for the improvement process. For this improvement process, the Supplier Involvement Scale is needed (*Supplier Involvement Scale.doc)*:
The average score obtained can be compared to the scores on the Supplier Involvement Scale. This provides the company with a check whether the obtained score is accurate. In addition to that, from the Supplier Involvement Scale the company can derive what it should do in order to obtain a higher score. The standard deviations can be used to check whether the purchasing and the R&D department agree on the topics under consideration. High standard deviations point out different opinions of the people answering the questions: this is a good starting point for further discussion of the analysis.

Instructions for answering the questions of the instrument:

Strategic questions
For the strategic questions, we ask you to focus on a single product development project that has been conducted by your organisation and that you have personal knowledge of.
Please make sure you are answering the questions for the same project as your colleagues have. The instructions are listed separately for the inputs, the throughputs and the outputs and apply to the blocks that are "active" after the instrument has been entered.

Conditions (Inputs)
Please provide the answers regarding your Business Unit (if your company does not consist of Business Units, please provide data regarding the total company).

Processes (Throughputs)
In this series of questions we ask you to make observations regarding specific activities that are carried out to prepare and organize supplier involvement in future development projects.

These activities are assumed to take place outside (not triggered by) one specific development project!

When answering the following questions:

1. please only think of the period before the project started;

2. please bear in mind that some activities can also be carried out outside the purchasing department (e.g. by the R&D department);

3. please bear in mind that the strategic management of suppliers can take place both in an informal and formal way.

Results (Outputs and priority setting)
The next set of questions focus on the development performance of the collaboration with all suppliers involved in the selected project. Below, we provide the definitions of performance indicators used. The indicators refer to the elements of the final product developed.

Element	this is refers to for example a component (ingredient), an assembly, a module or a subsystem that is part of the final product.
Supplier	includes both firms that contribute to development and/or engineering and/or manufacturing of the elements.
Technical performance	the functional performance, reliability and durability of the elements of the final product developed with suppliers.
Cost	the actual cost price as specified in the contract in the first year of delivery.
Development cost	costs related to internal development and engineering activities regarding those elements mainly developed by suppliers. This also includes any development expenses by suppliers as far as your firm pays them for.
Development lead-time	the time between the first moment of supplier involvement to the moment of release of the element (e.g., component, module).

Operational questions
For this survey, we ask you to focus on a single product development project that has been conducted by your organization and that you have personal knowledge of.
Please make sure you are answering the questions for the same project as your colleagues have. The instructions are listed separately for the inputs, the throughputs and the outputs and apply to the blocks that are "active" after the instrument has been entered.

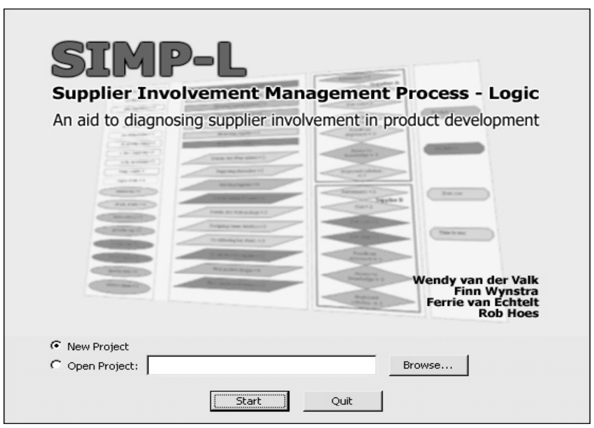
Conditions (Inputs)
Please provide the answers regarding the project under study.

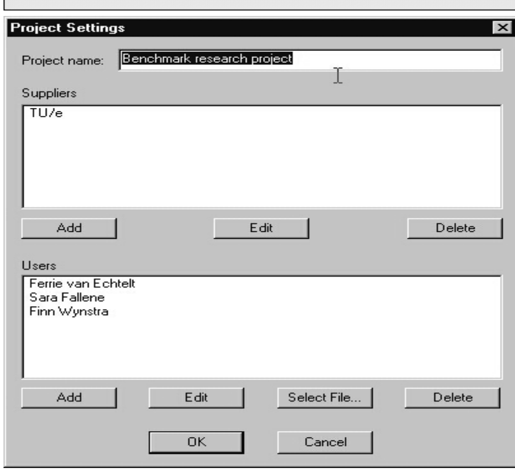
Processes (Throughputs)
In the series of project management questions, we ask you to make observations regarding specific activities to work with suppliers in the selected project. These activities could be carried out by one or more of the project team members.
In the series of collaboration management questions, we ask you to make observations regarding specific activities to work with one particular supplier in the selected project. These activities could also be carried out by one or more of the project team members.

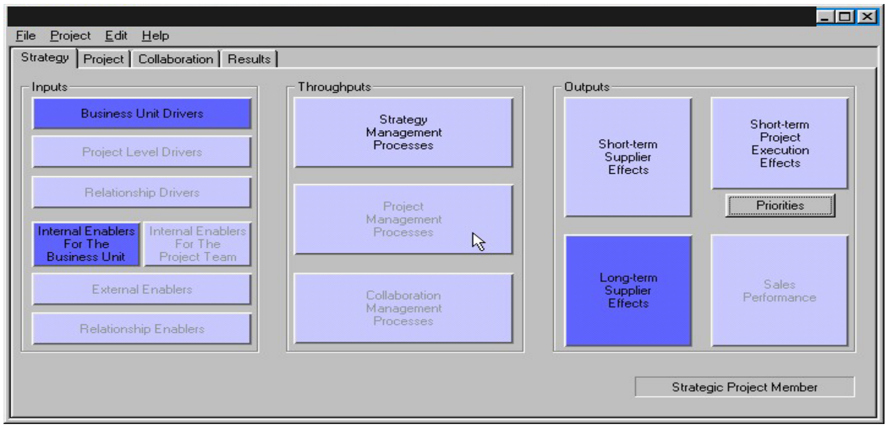
Results (Outputs and priority setting)
The next set of questions focus on the development performance of the collaboration with all suppliers involved in the selected project. Below, we provide the definitions of performance indicators used. The indicators refer to the elements of the final product developed.

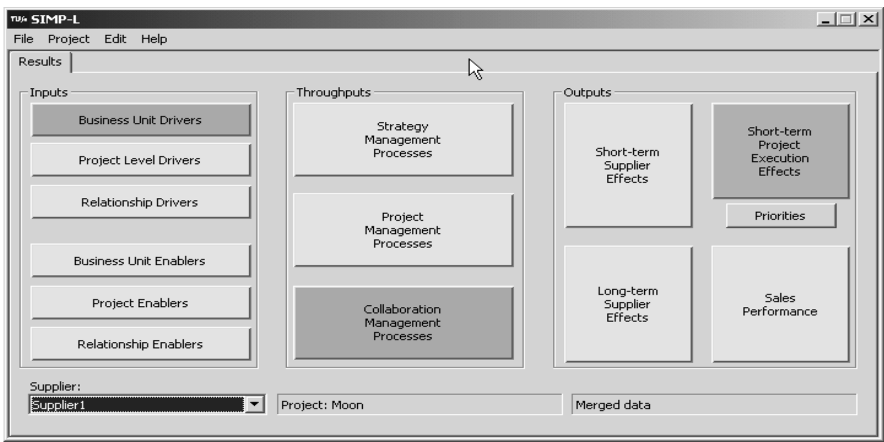
Element	this is refers to for example a component (ingredient), an assembly, a module or a subsystem that is part of the final product.
Supplier	includes both firms that contribute to development and/or engineering and/or manufacturing of the elements.
Technical performance	the functional performance, reliability and durability of the elements of the final product developed with suppliers.
Cost	the actual cost price as specified in the contract in the first year of delivery.
Development cost	costs related to internal development and engineering activities regarding those elements mainly developed by suppliers. This also includes any development expenses by suppliers as far as your firm pays them for.
Development lead-time	the time between the first moment of supplier involvement to the moment of release of the element (e.g., component, module).

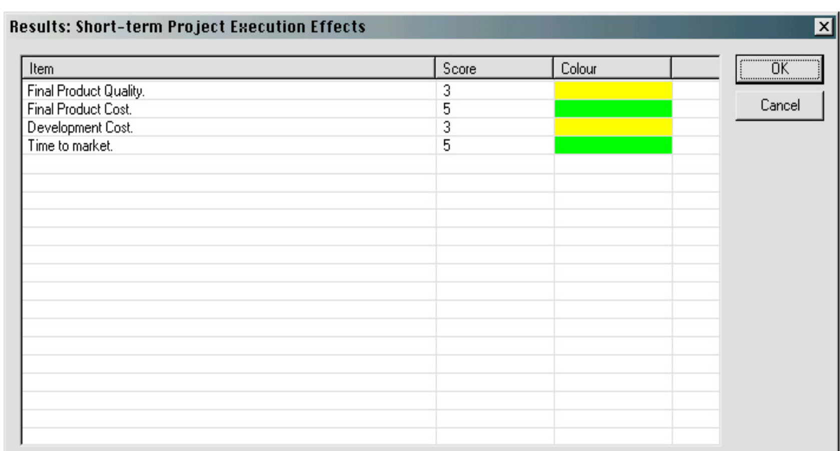
Some excerpts from the computer supported diagnosis instrument.






File Project Edit Help
Strategy Project Collaboration Results
Inputs
Business Unit Drivers
Project Level Drivers
Relationship Drivers
Internal Enablers For The Business Unit
Internal Enablers For The Project Team
External Enablers
Relationship Enablers
Throughputs
Strategy Management Processes
Project Management Processes
Collaboration Management Processes
Outputs
Short-term Supplier Effects
Short-term Project Execution Effects
Priorities
Long-term Supplier Effects
Sales Performance
Strategic Project Member


SIMP-L
File Project Edit Help
Results
Inputs
Business Unit Drivers
Project Level Drivers
Relationship Drivers
Business Unit Enablers
Project Enablers
Relationship Enablers
Throughputs
Strategy Management Processes
Project Management Processes
Collaboration Management Processes
Outputs
Short-term Supplier Effects
Short-term Project Execution Effects
Priorities
Long-term Supplier Effects
Sales Performance
Supplier:
Supplier1
Project: Moon
Merged data


Results: Short-term Project Execution Effects
Item
Score
Colour
Final Product Quality. 3
Final Product Cost. 5
Development Cost. 3
Time to market. 5
OK
Cancel

Appendix 7.7 Supplier Involvement Process Maturity Scale

SMP1: Formulating and communicating guidelines and blueprints for IPDS
1. No guidelines for internal departments have been formulated/ guidelines are formulated separately by the individual departments.
2. Guidelines are centrally formulated for internal departments.
3. Guidelines for internal departments are also formalised in written procedures.
4. Guidelines are also formulated for external suppliers.
5. Guidelines for external suppliers are also formalised in written procedures.
6. Guidelines are formulated in consultation with internal departments.
7. Guidelines are formulated in consultation with external suppliers.

SMP2: Determining internal versus external provisioning of technology
1. No clear policy with regard to insourcing/ outsourcing available.
2. Ad hoc approach to decision-making process insourcing/ outsourcing (crisis-related decisions and implementation).
3. Systematic, cross-functional decision-making based on internal and external (market) information.
4. Insourcing/ outsourcing decisions are taken with knowledge of current and potential supplier's short and long-term strategies and capabilities.
5. As per 4, but with clear objective setting and measurement.
6. As per 5, but with a formal implementation process.
7. Cross-organisational decision-making process resulting in clearly established core competencies.

SMP3: Surveying supplier markets for relevant developments
1. No scanning of supplier markets.
2. Ad hoc scanning of supplier markets for relevant competitive developments/ alternative technologies, including your current suppliers.
3. Proactive scanning of supplier markets for relevant competitive developments/ alternative technologies according to some sort of plan.
4. Scans are carried out systematically (according to some kind of plan).
5. Scans are carried out on a continuous basis (separated from project-related activities).
6. As per 5, and the scans are carried out cross-functionally.
7. As per 6, but the scans are customised to the wishes of internal customers.

SMP4: Pre-selecting suppliers for involvement in development activities
1. No pre-selection of suppliers takes place.
2. Ad hoc supplier pre-selection.
3. Suppliers are classified based on their usual roles and are involved according to these roles.
4. Supplier profiles are made based on suppliers' innovative capabilities and past experience of collaboration.
5. The supplier profiles are documented in a central supply database and made available to all relevant departments.
6. Supplier profiles are matched upfront with preferred supplier roles to be fulfilled in product development. Past supplier performance is used in updating the preferred supplier list.
7. Supplier profiles are matched upfront with preferred supplier roles to be fulfilled in product development, in consultation with suppliers.

SMP5: Leveraging suppliers' skills and capabilities
1. Development takes place with a strong emphasis based on internal developments.
2. As per 1, but the organisation applies the technical standards of the supplier market to internal developments.
3. As per 2, but the organisation carefully analyses upfront where it can use existing suppliers' components in development.
4. As per 3, external supplier capabilities and supplier driven technological developments are taken as a starting point for own development activities.
5. As per 4, but the organisation occasionally draws own technology and product roadmaps and matches them with future supplier capabilities.
6. As per 5, but matching is updated on a periodic basis in consultation with key suppliers and uses a structured format. Key suppliers are involved in advanced development and testing of parts or technologies for application in future development projects.
7. As per 6, but new ideas/ development activities are generated in consultation with the supplier on a continuous basis using a variety of pre-designed formal and informal knowledge sharing mechanisms (f.e. supplier technology fairs, steering committees, informal contacts of development team member with suppliers).

SMP6: Motivating suppliers to develop knowledge and/ or skills

1. Suppliers are not actively motivated to be involved in product development projects (it is taken for granted that they come up and incorporate their ideas in achieving the targets).
2. Suppliers are occasionally asked to develop customised parts or modules.
3. Suppliers are occasionally asked to invest their resources in specific technological areas (e.g. Manufacturing equipment, electronics engineering capability) which are relevant for future product development projects, bringing this in line with your technology roadmap.
4. Future production volumes are formally used as an incentive to motivate the supplier to invest in and develop particular skills or parts.
5. Other incentives that could increase the ability of you as a customer to motivate the suppliers are intentionally used (e.g. reputation).
6. A careful upfront analysis of all possible ways to motivate suppliers is carried out.
7. A complete business case is presented to and discussed with the supplier including planning, timing, volume, arrangements regarding the use of jointly developed innovations and formal risk and reward sharing.

SMP7: Evaluating guidelines and blueprints for IPDS

1. Guidelines for internal departments and external guidelines are hardly ever evaluated to check whether they are followed and whether they are still sufficient.
2. Guidelines for internal departments are occasionally evaluated whether they are followed.
3. Guidelines for internal departments are occasionally evaluated whether they are still sufficient.
4. Guidelines for external suppliers are occasionally evaluated whether they are followed.
5. Guidelines for external suppliers are occasionally evaluated whether they are still sufficient.
6. Guidelines for both internal departments and external suppliers are systematically evaluated based on analysis of best practices and mistakes in past developments projects.
7. Guidelines for external suppliers are also evaluated based on feedback on the guidelines themselves obtained from suppliers.

PMP1: Developing project-specific develop-or-buy options

1. The project team does not actively divide the final product into separate building blocks upfront in order to determine for which supplier will be involved in development.
2. The project team is actively involved in the definition of the building blocks for which suppliers are going to be involved in the development.
3. The project team uses the insourcing/ outsourcing policy as a strong guideline.
4. The project team is actively involved in determining the preferred supplier role in the development of the identified building blocks.
5. As per 4, and the preferred supplier roles are based on a standard categorisation describing clearly characteristics regarding the division of labour and responsibilities.
6. As per 5, and standard designs/ formats with regard to suppliers' responsibility are present.
7. As per 6, and supplier responsibility is determined in consultation with potential suppliers.

PMP2: Suggesting alternative suppliers/ technologies/ components

1. No information on alternative suppliers/ technologies/ components is collected.
2. Information on alternative suppliers/ technologies/ components is collected.
3. As per 2, and these alternative suppliers/ technologies/ components are further evaluated during the project.
4. Information available from permanent market scanning activities (SMP3) is also used to identify alternative suppliers/ technologies/ components.
5. Existing and potential suppliers are asked to suggest alternative technologies/ components.
6. As per 5, and the information generated within specific projects is fed back to a (joined) R&D and purchasing information database.
7. As per 6, and documentation from previous projects is used for future projects.

PMP3: Selecting suppliers for project involvement

1. No formal selection process present/ suppliers are selected based on implicit, subjective criteria.
2. Suppliers are arbitrarily chosen depending on the existing contact network within the organisation.
3. Departments inform/ consult with each other, but suppliers are selected based on one-dimensional criteria.
4. Cross-functional approach to supplier selection.
5. The project team is actively involved in explicitly defining project-specific supplier selection criteria.
6. As per 5, and criteria are measured and assessed formally.
7. As per 6, and results of assessments are used for renewed supplier categorisation.

PMP4: Determining timing and extent of involvement

1. No clear time schedule in advance of the project, no differentiation with regard to the involvement of different types of suppliers.
2. Supplier classification (SMP4) is used to differentiate the timing of involvement of different suppliers.
3. Timing of involvement is based on the development work-package.

4. As per 3, but suppliers are requested for input with regard to timing.
5. As per 4, and suppliers' responsibilities are clearly determined before the project starts.
6. As per 5, and decisions with regard to timing and responsibilities are recorded/ documented and followed.
7. As per 6, and documentation from previous projects is used for decision-making in future projects.

PMP5: Coordinating development activities horizontally between different first tier suppliers
1. Project team is not involved in co-ordinating external development/ engineering activities.
2. Ad hoc co-ordination between different first tier suppliers.
3. Co-ordinating activities take place by means of informal communication, main objective is keeping everyone involved in the project informed of progress and performance (in order to create commitment to project).
4. Co-ordinating activities take place regularly. Formalised meetings are held to monitor progress.
5. Co-ordination activities are adapted based on the needs of the evolving project.
6. As per 5, but the co-ordination activities are also adapted based on the feedback obtained during the project from involved suppliers.
7. As per 6, and a database of experiences is created/ used/ maintained as a source of knowledge for new projects.

PMP6: Evaluating project execution
1. No formal project evaluation is in place.
2. Project is internally evaluated in an informal manner.
3. Evaluation criteria are made explicit along with suitable measurements.
4. As per 3, and based on this, project evaluation is carried out in a formal manner (internally).
5. As per 4, but suppliers are informally involved in the evaluation process.
6. As per 5, but suppliers are involved in the formal evaluation procedure.
7. As per 6, and evaluation results are fed back to the guideline formulation process.

CMP1: Jointly determining the development work-package
1. No clear agreement between manufacturer and supplier about development activities and responsibilities present.
2. Manufacturer explicitly determines targets and deadlines (internally).
3. Targets and deadlines are discussed with supplier. Supplier can give input with regard to target setting and timing of deliverables.
4. Supplier development activities are formalised in a project agreement.
5. Project team is involved in specifying contractual conditions in a formal contract.
6. As per 5, and standard project agreements in combination with certain contracts are available.
7. As per 6, but contractual conditions are determined in consultation with the supplier.

CMP2: Determining the communication interface between customer and supplier
1. No communication structure defined up-front.
2. Project team is occasionally involved in determining communication structure between manufacturer and first tier suppliers, between first tier suppliers and their sub-suppliers and between different first tier suppliers.
3. A systematic approach to determining communication structure between manufacturer and first tier suppliers, between first tier suppliers and their sub-suppliers and between different first tier suppliers is present.
4. Communication structure is defined according to guidelines for involving suppliers in product development (SMP1).
5. As per 4, and the database of experiences from past projects (CMP3) is used as input when determining the communication structure.
6. As per 5, and communication is formalised by means of appointing somebody for recording and documentation. Formal meetings are planned.
7. As per 6, but suppliers are consulted when determining the communication structure.

CMP3: Co-ordinating development/ engineering activities customer vs. suppliers
1. Project team is not involved in co-ordinating external development/ engineering activities.
2. Ad hoc co-ordination between manufacturer and first tier suppliers, between first tier suppliers and their sub-suppliers and between different first tier suppliers.
3. Co-ordinating activities take place by means of informal communication, main objective is keeping everyone involved in the project informed of progress and performance (in order to create commitment to project).
4. Co-ordinating activities take place regularly according to the predefined interfaces (CMP1 and CMP2). Formalised meetings are held to monitor progress.
5. Co-ordination activities are adapted based on the needs of the evolving project.
6. As per 5, but the co-ordination activities are also adapted based on the feedback obtained during the project from involved suppliers.
7. As per 6, and a database of experiences is created/ used/ maintained as a source of knowledge for new projects.

CMP4: Evaluating building block design
1. No formal component/ module evaluation is in place.

2. Component is evaluated with regard to technical aspects (technical performance, serviceability, safety, makeability, et cetera).
3. Component is evaluated with regard to commercial aspects (cost, lead-time, availability, et cetera).
4. Project team is occasionally involved in investigating possibilities for standardisation and simplification of building blocks.
5. As per 4, and improvement programme is started to standardise or simplify building blocks.
6. As per 5, and standardised and/ or simplified building blocks are used as basic building blocks for future developments.
7. As per 6, and a structural approach for evaluation/ standardisation/ simplification is in place.

CMP5: Evaluating and feeding back suppliers' development performance

1. No formal supplier evaluation is in place.
2. Supplier is internally evaluated in an informal manner.
3. Evaluation criteria are made explicit along with suitable measurements.
4. As per 3, and based on this, supplier evaluation is carried out in a formal manner (internally).
5. As per 4, and the results of the evaluation are fed back to the supplier/ supplier responds to results evaluation.
6. As per 5, but suppliers also evaluate manufacturer's performance.
7. As per 6, and an improvement programme is started by the supplier or jointly by supplier and manufacturer.

Appendix 8.1 Action Research Steering Committee and Project Team meeting Océ

Date	Action research meetings
22 March 2002	Steering committee meeting
24 April 2002	Project team meeting
28 May 2002	Project team meeting
11 June 2002	Meeting new Vice-President Purchasing
1 October 2002	Steering committee meeting
14 October 2002	Project Team meeting
25 November 2002	Project Team meeting
16 December 2002	Project Team Meeting
23 January 2003	Project Team meeting
28 January 2003	Steering committee
22 May 2003	Steering committee
3 June 2003	Supply Base Manager
16 July 2003	Project Team meeting
22 July 2003	Steering committee

Appendix 8.2 Action research case interviews and presentations

Date	Interviews/presentations and representatives involved
10 June 2002	Interview Supplier involvement typologies and issues, Vice-President Manufacturing
13 June 2002	Interview Supplier involvement typologies and issues, Functional Team Manager Electronics
19 June 2002	Interview Supplier involvement typologies and issues, Purchasing Project Manager
10 July 2002	Interview Supplier involvement typologies and issues, Mechanical Engineering Manager
18 July 2002	Interview Supplier involvement typologies and issues, Manufacturing Unit Manager
22 August 2002	Interview Supplier involvement typologies and issues Manufacturing Engineering Unit mgr
22 August 2002	Interview Supplier involvement typologies and issues Manufacturing Project Leader
22 August 2002	Interview Supplier involvement typologies and issues Account Buyer
4 December 2003	First series case studies validation: (PBA image processing, Main Frame, Power supply) Functional Team Manager Electronics, R&D Electronics and Mechanical engineers, Manufacturing and Logistics project leader, engineers, account buyers.
6 February 2003	Presentation initial design supplier contribution instrument to Cross-functional External Mechanical Engineering team
22 April 2003	Presentation supplier contribution instrument to various internal representatives R&D engineer electronics, R&D, project engineering leader, Commodity Team Leader, Manufacturing and Logistics project leader
29 April 2003	2nd series Case studies / Group interview 'Controller 1 en 2' (R&D Project leader, R&D mechanical engineer, Manufacturing Engineer, Account Buyer)
29 April 2003	2nd series Case studies / Group interview 'Print Receiving Unit 1 en 2' (R&D Project leader, R&D mechanical engineer, Manufacturing Engineer, Account Buyer)
16 May 2003	2nd series Case studies / Group interview 'Paper Input Module' (R&D engineer electronics, Manufacturing Engineer, Account Buyer)
16 May 2003	2nd series Case studies / Group interview 'Scan Unit' (R&D engineer electronics, Manufacturing Engineer, Account Buyer)
16 May 2003	2nd series Case studies / Group interview 'User Interface' (R&D engineer electronics, Manufacturing Engineer, Account Buyer)
12 June 2003	Design Supplier contribution instrument Account Buyer
26 June 2003	Design Supplier contribution instrument Account Buyer

Appendix 8.3 Overview cases regarding supplier contribution characteristics and possible shifts

	Buy Part	Development Tactic start ➔ end	Significant events and dynamics
1	Stapler Head F-project	D➔C (Purch) D = D (R&D)	Buyer: standard supplier part becomes increasingly customised due to Océ specific change requests
2	Air Lid F-project	A = A	Low supplier development responsibility; Océ designed part with some input on manufacturability
3	Machine Frame F-project	A = A	Océ designed frame and involved supplier on manufacturability aspects
4	User Interface F-project	C➔B	Supplier is explicitly given full development responsibility for electronics and display. Although supplier assembles UI including plastic housing, it has not been involved for design of housing. Occurrence of coordination and quality (control) problems
5	Sheet Input Unit F-project	C➔B 1st supplier B➔A 2nd supplier	First engineering partner involved based on a sketch and functional requirements. Result: no properly functioning design. 2nd supplier is involved based on 2D drawings and an engineering prototype. Supplier designs single sheet metal components and assembles other components specified by Océ. Supplier provides production-engineering input.
6	Print Receiving Unit F-project	B➔A	Supplier involved for production engineering. However contribution is larger affecting lay-out and design. Later on, design change management responsibility kept inside Océ
7	Motor F-project	D (right) ➔ D-(left)	Buyer states that a standard supplier part becomes increasingly customised due to Océ specific change requests aimed at meeting EMC norms
8	Sensor F-project	C➔ B	Océ does not appear to have enough knowledge on sensor and ends up with an expensive and hard-to-manufacture sensor design.
9	Image Processing PBA F-project	A➔A	Low supplier development responsibility; Océ has designed the part and outsourcing manufacturing of PBA to a supplier with some input on manufacturability etc.
10	Engine Power supply –F project	C➔C	Successful outsourcing of full development. Collaboration was intensive and interactive though
11	Print Receiving Unit K-project	B➔ Complete insourcing	Supplier involved based on a global design and initial prototype. Is asked to engineer the part improving integrally Q,C, Service aspects. Océ does not provide stable functional requirements, high interaction.
12	Separation Fan K-project	A = A	Low supplier development responsibility; Océ has designed the part with some input on manufacturability
13	Power supply K-project	C = C	Supplier performs satisfactorily complete design, engineering production tasks
14	Motor K-project	C➔B	Supplier performs electro-mechanical design tasks but lacks electronics design expertise --> increase in Océ design input
15	Ink-supply G-project	B➔A	More input was expected from supplier in designing components for Ink supply unit. Océ took over in the end, but manufacturability issues still existed.
16	Controller G-project	D➔B (Purch+MQ) D = D (R&D)	A standard supplier part is subject to customisation questions and in particular validation and assembly related tasks. R&D-employee states that basic development tactic remains D, perhaps moves from right to left.
17	Scan Unit G-project	C➔ B	Supplier asked to coordinate design of parts involving multiple design disciplines. Océ underestimates cost targets and intermediate design quality: Supplier not considered capable of assessing design contribution electronics suppliers and incoming quality for assembling total scan unit. insourcing electronics design related tasks; However, full design responsibility for important Lens component in Scan Unit

	Buy Part	**Development Tactic start ➔ end**	**Significant events and dynamics**
18	Door Assy G-project	A➔A	Low supplier development responsibility; Océ has designed the part with some input on manufacturability
19	Top Cover G-project	A➔B	Low supplier development responsibility; Océ has designed the part with some input on manufacturability
20	Spring Assy's G-project	A➔A	Low supplier development responsibility; Océ has designed the part with some input on manufacturability
21	User-Interface G-project	C➔C	Successful outsourcing of full development regarding User Interface to supplier
22	Main frame C-project	B➔A	The frame has been largely design by the supplier in close interaction with Océ however, the other parts that together make up the frame assembly have been designed and specified by Océ. Problems occur at the level of the assembly not specifically for the frame itself.
23	Magnet Roller C-project	B➔A	The magnet roller assy has been clearly subject to engineering problems Supplier was experienced in magnetism however not in designing complete assembly and sourcing other parts
24	Image Processing PBA F-project	A➔A	Low supplier development responsibility; Océ has designed the part and outsourcing manufacturing of PBA to a supplier with some input on manufacturability etc.
25	Engine Power supply – F project	C➔C	Successful outsourcing of full development. Collaboration was intensive and interactive though

Appendix 8.4 Tables Key attention areas for managing supplier involvement in product development

B. Primary buyer/supplier capabilities and value added per collaboration type				
Characteristics	**Collaboration A**	**Collaboration B**	**Collaboration C**	**Collaboration D**
Capabilities supplier	Production /assembly process industrialisation (sourcing, logistics, early component/material supplier involvement)	Expert in manufacturing technologies; Value engineering, Access to low cost supply base Effective, flexible logistics chain	Functional knowledge and own technologies preferably in printer applications	Independent, own product development and production
Value Added supplier	Low-cost lean manufacturing Production	Optimising design using diverse engineering disciplines and production/process technologies + Sourcing and logistics	Full-design trajectory including concept development	Ready / off-the-shelf product
Value Added Océ	Fully detailed design, choice production technologies and manufacturing prototypes and possibly suggest supply base for components	Functional knowledge engineering concept Clearly defined interfaces	Application knowledge to be able to define functional requirements	integrator complete delivered systems/product
Costs	Tooling, few project/ start up costs	Prototype, engineering costs, Industrialisation, tooling costs	Development costs (design, engineering and industrialisation)	contracting and possibly licencing costs

C. Collaboration preparation requirements for customer organisation (buyer)				
Characteristics	**Collaboration A**	**Collaboration B**	**Collaboration C**	**Collaboration D**
Quality level (degrees of freedom) **design/ specifications**	Detailed Technical Documentation released Manufacturing Prototype functionality demonstrated	Part functionality specified, Functional feasibility proven through global design (3D drawings set up) and first prototype Stable interfaces with adjacent parts	Functional product requirements and additional design constraints determined	Functional requirements and technical specs are available. Verification of match between supplier specification and own requirements
Moment of involvement	In the phase towards Reference Engineering Prototype	Phase towards Engineering Prototype	Towards Laboratory Prototype	Depending on need

D. Characterisation of the operational collaboration, organisation and process				
Characteristics	**Collaboration A**	**Collaboration B**	**Collaboration C**	**Collaboration D**
Organisational governance	Formal, informing focus on "consolidating" Part Quality Planning and limited Early Supplier Involvement	Formal project management intensive / interactive focus on "optimising design while preserving part functional specifications and concept" Extensive Early Supplier Involvement meetings	Formal project management Tight / interactive focus "developing together supplier is strong sparringpartner" Early supplier involvement meetings	Extensive project organisation barely applicable focus is on assuring and informing regarding obsolete components or supplier product introductions or other changing conditions
Communication direction and content	Verification of manufacturability, part availability, costprice, Océ engineer clarifies drawings and tolerances. Limited adaptation to tolerances possible	Via teams, Jointly considering alternative solutions for improving different design aspects verification of meeting technical and commercial targets Two-way communication	Via specialist representatives and commercial counterparts Validation concept en requirements Two-way communication	Largely via Purchasing, Océ needs primarily technical information from supplier and commercial information for fixing contract and organising operational delivery
Collaboration process: behaviour/ attitude	Océ --> attitude is open regarding limited range of design aspects: aimed at soliciting feedback on specified measures and tolerances that possibly undermine manufacturabil ity	Open: pro-active attitude to jointly evaluate alternative production technologies and specific construction improvements (Value engineering) resulting in QC,T etc. benefits.	Supplier poses critical questions to understand the requirements for developing a concept and engineer the concept Attitude Océ is aimed providing the right level and stability of requirement info and test feedback to supplier	Océ communicates technical and commercial requirements Supplier communicates conditions for exchange to take place
Mutual Team composition	Océ representatives from operations and Purchasing and limited representation of the R&D engineer involved in engineering and drawing	Dedicated teams, especially R&D engineers from all relevant disciplines and representatives from operations and Purchasing	Especially development engineers. Development possibly at customer's premises	Primarily Purchasing and Sales with technical spokes persons as back up
Reporting format	Limited reporting, especially aimed at delivery times	Reporting based on different intermediate milestones and cost and quality related targets	Reporting based on different intermediate milestones and cost and quality related targets	Based on sample checking validating /verifying promised functionality

E. Contractual and legal governance elements

Characteristics	Collaboration A	Collaboration B	Collaboration C	Collaboration D
Contract type	Supply contract	Engineering contract based on agreed targets regarding important engineering and delivery targets. Compensation based on number of agreed engineering hours and prototype costs per phase	Development contract identifying deliverables in different phases and backed-up by a contingency plan. Contract is committed by management; compensation possible based on estimated hours, fixed payment or amortisation over total production series during life-cycle	Licencing and supply contract explicitly assuring Quality, Logistics and Price in separate sections
Intellectual property	Océ	Océ	Océ or Supplier	Supplier
Design exclusivity				
Liability				
Creation Technical Documentation during collaboration (PDP)	Océ	Océ or Supplier	Océ or Supplier	Supplier
Maintenance and implementation for design changes	Océ	Océ or Supplier	Océ or Supplier	Supplier

Samenvatting (summary in Dutch)

In dit proefschrift hebben we empirisch onderzocht hoe bedrijven externe leveranciers effectief kunnen betrekken in het ontwikkelen van nieuwe producten. Het vertrekpunt van de studie vormt de observatie dat eerdere studies vooral een wisselend beeld rapporteren t.a.v. de daadwerkelijk behaalde resultaten van dergelijke betrokkenheid. Zij wijzen erop dat bedrijven zich wel bewust zijn geworden van de potentiële voordelen, maar vaak nog onvoldoende inzicht hebben in de manier waarop zij daadwerkelijk de doelstellingen kunnen realiseren. Het is daarom gerechtvaardigd om de kritische management activiteiten en noodzakelijke condities waarin bedrijven samenwerkingen met leveranciers in productontwikkeling starten verder te onderzoeken. De centrale onderzoeksdoelstellingen zijn tweeledig:

- het in kaart brengen en vaststellen van de management activiteiten en condities welke ten grondslag liggen aan het effectief gebruik maken van externe leveranciersexpertise ten behoeve van korte en lange termijn verbetering van productontwikkelingsprestaties.
- het ontwikkelen van een analytisch raamwerk dat als referentie functioneert bij het diagnosticeren en verbeteren van het managen van leveranciersbetrokkenheid in productontwikkeling.

Op basis van een breed overzicht van de trends die ten grondslag liggen aan de toenemende betrokkenheid van leveranciers in productontwikkeling (zie Hoofdstuk 1) en een uitgebreide literatuurstudie (zie Hoofdstuk 2), hebben we de volgende onderzoeksvragen geformuleerd:

1. *Welke korte en lange termijn doelstellingen liggen ten grondslag aan de intentie van een bedrijf om leveranciers te betrekken in productontwikkeling?*
2. *Welke management activiteiten zijn kritisch in het realiseren van de korte en lange termijn doelstellingen van leveranciersbetrokkenheid?*
3. *Welke factoren ondersteunen daadwerkelijk de uitvoering van de management activiteiten gericht op het managen leveranciersbetrokkenheid in productontwikkeling?*
4. *Welke contextuele factoren vergroten de noodzaak voor het uitvoeren van de verschillende management activiteiten?*
5. *Hoe kan een analytisch raamwerk worden gebruikt als referentie bij het diagnosticeren en verbeteren van de activiteiten en condities ten behoeve van het managen van leveranciersbetrokkenheid in productontwikkeling?*

In de eerste literatuurstudie hebben we een overzicht van bestaande literatuur verschaft waarbij vijf clusters zijn onderscheiden. We hebben vervolgens deze clusters beschreven en vergeleken in termen van het gehanteerde theoretisch perspectief, de eenheid van analyse en de ontwikkelde conceptuele modellen. Daarbij onderscheiden eerdere bijdragen van Wijnstra (1998), Monczka etal. (2000) en Takeishi (2001) zich van andere studies door het brede perspectief op het intern en inter-organisatorisch management van leveranciersbetrokkenheid. Andere studies hanteren een enger perspectief en zijn veelal gericht op het bestuderen van (kenmerken van) de klant-leverancier relatie, van de samenwerking in een ontwikkelingsproject of van de inkoopafdeling als hoofdpersoon en zijn betrokkenheid in product ontwikkeling en het managen van leveranciersbetrokkenheid. We stellen dat een breder (geïntegreerd) perspectief zowel onderzoeker als bedrijven beter in staat stellen begrip te ontwikkelen van dit complexe fenomeen.

Als vervolgstap hebben we een bestaand analytisch raamwerk geselecteerd dat uitgaat van een contingentiebenadering in het managen en organiseren van leveranciersbetrokkenheid (zie Hoofdstuk 3). Het 'Geïntegreerde raamwerk voor Inkoopbetrokkenheid in productontwikkeling' vormde een belangrijk vertrekpunt (Wynstra et al., 1999). In dit raamwerk worden verschillende groepen van management activiteiten onderscheiden welke zijn ondergebracht in vier gebieden elk met een specifiek karakter en functie (bijv. korte-lange termijn). De activiteiten zijn toegevoegd aan het raamwerk op basis van hun bijdrage aan vijf onderliggende processen. Verder worden zogenaamde 'enabling factoren' onderscheiden welke de uitvoering van de management activiteiten ondersteunen. De laatste bouwsteen vormen de 'driving factoren' welke de noodzaak voor en de vorm van uitvoering van management activiteiten bepalen. Alvorens onze veldstudie daadwerkelijk te beginnen, hebben we additionele literatuur geraadpleegd en kwamen tot de conclusie dat enkele aanpassingen in het gekozen raamwerk noodzakelijk waren. Allereerst hebben we twee groepen van doelstellingen toegevoegd om de resultaten van leveranciersbetrokkenheid op korte en lange termijn te kunnen meten. Verdere aanpassingen bestonden uit het toevoegen van extra relevante enabling and driving factoren, welke tevens gegroepeerd zijn op drie niveaus van analyse. Ten slotte hebben we de naam van het originele raamwerk veranderd in 'Integrated Product Development and Sourcing' (IPDS). Hiermee geven we het belang aan om leveranciers betrokkenheid te bezien als het integreren van het productontwikkelingsproces met processen om externe leveranciersexpertise te gebruiken. Daarmee reduceren we de a priori nadruk op de rol van een specifieke afdeling (inkoop) in het managen van leveranciersbetrokkenheid. Het resultaat is een eerste revisie van het gekozen raamwerk.

We vervolgden het onderzoek met de veldstudies gebruikmakend van een gecombineerde toepassing van kwalitatieve onderzoeksmethodologieën bestaande uit longitudinale en cross-sectionele gevalstudies en actie-onderzoek. Deze combinatie en volgorde van methodologieën passen bij de complexe aard van het fenomeen en de type onderzoeksvragen. Acht ingebedde gevalstudies van leveranciersbetrokkenheid zijn uitgevoerd bij Océ[4]. Daarbij hebben we nauwkeurig onderzocht op welke wijze Océ samenwerkingen met leveranciers in productontwikkeling opzet en uitvoert (zie hoofdstuk 4). De studie heeft een rijke historische beschrijving van gebeurtenissen opgeleverd en geresulteerd in een eerste inzicht in de kwesties en problemen bij het managen van verschillende typen leveranciersbetrokkenheid.

[4] Een Nederlands bedrijf dat gespecialiseerd is in het ontwikkelen en assembleren van printers voor professionele gebruikersomgevingen en het verschaffen van verschillende complementaire diensten gericht op het beheer van documenten (stromen).

Onze analyse van de gevalstudies met behulp van het analytisch raamwerk (zie Hoofdstuk 5) verschaften inzichten in welke management activiteiten en hun uitvoeringsvorm hebben bijgedragen aan de samenwerkingen die zowel conform als niet-conform doelstellingen presteerden. De analyse van de aanwezige condities (enabling en driving factoren) gaf ons een aanvullend en completer inzicht in waarom Océ juist effectief de leverancier kon betrekken en waarom juist niet. Kritische activiteiten waren de mate en de wijze waarop Océ leveranciers (voor)selecteert en het uit te besteden onderdeel zorgvuldig definieert en de bijbehorende doelstellingen communiceert en afstemt met toeleveranciers gedurende de samenwerking. Onze voorlopige conclusie was dat het raamwerk voldoende in staat was een plausibele en overtuigende verklaring te verschaffen in het hoe en waarom van effectieve en teleurstellende samenwerkingen met leveranciers. Echter aanvulling van het raamwerk en precisering t.a.v de relevante activiteiten en condities was noodzakelijk. Bovendien, bleek het onderscheid tussen de vier management gebieden onvoldoende de realiteit in de praktijk weer te geven.

Deze inzichten hebben geleid tot een herconceptualisering en verdere aanvulling van het raamwerk (zie Hoofstuk 6). In plaats van vier management gebieden onderscheiden we de '*Strategische Management Arena*' en de '*Operationele Project Management Arena'* waarbij een 'arena' gedefinieerd wordt als een 'werkgebied van activiteiten'. De Strategische Management arena bevat zeven processen die gezamenlijk lange termijn, strategische richting geven en operationenele ondersteuning voor productontwikkelingsteams. Deze processen dragen ook bij aan het opbouwen van een leveranciersbasis welke toegankelijk, gemotiveerd en kundig is gegeven de huidige en toekomstige technologieën en benodigde competenties.
De '*Operationele Project Management Arena'* bevat negen processen welke gericht zijn op het plannen, besturen, coördineren en evalueren van samenwerkingen in een specifiek ontwikkelingsproject. De twee arena's zijn zowel opzichzelfstaand als onderling afhankelijk, gegeven de noodzaak om op elk ogenblik korte termijn belangen en doelstellingen verbonden aan productontwikkelingsprojecten af te stemmen met het lange termijn beleid op het gebied van technologieën en andere competenties. Wat betreft de driving en enabling condities voor leveranciersbetrokkenheid, hanteren we nu dezelfde niveaus van analyse: factoren die waarneembaar zijn op het niveau van de samenwerking met een leverancier, op het niveau van het projectteam en ten slotte op het niveau van de totale organisatie van de business unit/bedrijf. Bovendien, zijn enkele nieuwe factoren toegevoegd.

Vervolgens hebben we de verworven inzichten vergeleken met de praktijk van andere bedrijven opererend in verschillende industrieën, door het herziene raamwerk toe te passen in additionele gevalstudies (zie Hoofdstuk 7). Het betrof hier de bedrijven HJ Heinz, PANalytical, Philips Domestic Appliances (DAP) and Boon Edam. Acht ontwikkelingsprojecten zijn onderzocht waarbij we hebben ingezoemd op 1 tot 2 samenwerkingen met leveranciers. Op deze manier kon worden onderzocht in hoeverre de procesen in de strategische en operationele management arena ook plausibele en valide verklaringen konden verschaffen voor succesvolle en problematische samenwerkingen. Behalve het testen van de validiteit/robuustheid van het raamwerk hebben we aansluitend in samenwerking met deze bedrijven het raamwerk doorontwikkeld als een zelfdiagnose instrument. Het raamwerk bleek waardevolle inzichten te verschaffen in de kritische factoren en besluitvormingsprocessen die ten grondslag lagen aan succesvolle en problematische projecten (samenwerkingen).

Succesvolle samenwerkingen werden ondersteund door een cross-functionele organisatie van tenminste Inkoop en R&D afdelingen. Verder konden de projecten profiteren van een geprekwalificeerde leveranciersbasis en hadden gelijktijdig oog voor korte termijn projectdoelstellingen en lange termijn strategische belangen voor toekomstige projecten gedurende het managen van de samenwerking. De evaluatie van de prestaties van beide partijen en de onderliggende processen en richtlijnen is een sleutelfactor dat het leren en verbeteren van samenwerkingen en besluitvorming bevordert. Daarbij werd duidelijk dat de aansluiting van tweedeling in management arenas bij de realiteit van managers nog verder verbeterd kon worden door naast de strategische management arena een arena voor project management en een arena voor het management van de individuele samenwerking te onderscheiden. Daarom onderscheiden we ook coördinatie- en evaluatieprocessen in alle management arena's.

Als laatste onderzoeksvraag hebben we de verbetering van een van de management processen gericht op leveranciersbetrokkenheid geadresseerd via actie-onderzoek bij Océ (zie Hoofdstuk 8). Uit de twee series case studies bij Océ en bij de vier andere bedrijven kwam naar voren dat het voorselecteren van leveranciers en daarmee toegang creëren tot de juiste kennis en kunde in aangewezen technologische gebieden een scharnierpunt is voor effectieve betrokkenheid. Dit inzicht was de aanleiding om met Océ daadwerkelijk dit proces verder uit te diepen en richtlijnen te ontwikkelen hoe dit proces effectief uit te kunnen voeren. In nauwe samenwerking met vertegenwoordigers van inkoop, productie en R&D afdelingen en met regelmatige raadpleging van literatuur werd een reflectie- en veranderingsproces gecreëerd waarbij het eindresultaat zowel nieuwe theoretische kennis als een praktisch instrument is. De kennis bestond uit waarom bedrijven een gemeenschappelijk begrip en visie moeten ontwikkelen t.a.v. de bijdragen van leveranciers dat het verlangt in productontwikkeling. Veel samenwerkingen worden ondermijnt door een gebrek aan duidelijke verwachtingen omtrent elkanders rol en bijdragen gedurende verschillende fasen van een project en op langere termijn. Het afstemmen van deze verwachtingen is alleen mogelijk indien een gemeenschappelijke herkenbare set van begrippen gehanteerd wordt waarmee verschillende afdelingen met elkaar en met leveranciers kunnen communiceren omtrent elkaars verwachtingen. Het instrument ontwikkeld bij Océ verlegt de gebruikelijke aandacht voor het kiezen van leverancierstypen eerst naar het kiezen van gewenste bijdragen van leveranciers.

Ons theoretisch en empirisch onderzoek hebben geresulteerd in twee uitkomsten. Allereerst heeft het onderzoek een nieuw inzicht verschaft door een breed geïntegreerd perspectief op de condities en processen die nodig zijn om leveranciersbetrokkenheid effectief te kunnen managen. Dit perspectief wordt gedragen door een analytisch raamwerk. Het is gebaseerd op een bestaand model en is verder ontwikkeld op basis van verschillende cycli van reflectie op inzichten uit de literatuur en empirische data. De inzichten zijn verder verankerd in theorieën beschikbaar in studies in strategisch management, organisatiekunde en productontwikkeling.

De tweede uitkomst van deze studie is een aan de praktijk getoetst diagnostisch instrument dat het mogelijk maakt om sterke en zwakke aspecten van besluitvorming en samenwerking intern tussen R&D en Inkoop en met leveranciers kunnen blootleggen. Het instrument wordt ondersteund door een softwareprogramma en kent een gebruikersvriendelijke interface. Het vormt een van de middelen om op een gestructureerde wijze het management van leveranciersbetrokkenheid in verschillende arena's (strategisch, project, samenwerking) en t.a.v. verschillende typen condities te analyseren en te verbeteren. De bijdrage van dit proefschrift is daarmee niet beperkt tot het toevoegen van nieuwe inzichten aan de theoretische kennis op het gebied van leveranciersbetrokenheid. De inzichten zijn vervat in praktische aanbevelingen die professionals in R&D en Inkoop ondersteunen in het vormen en implementeren en verbeteren van een effectieve leveranciers-betrokkenheidstrategie.

About the Author

Ferrie van Echtelt (1975) studied International Business Studies at Maastricht University and graduated in 1998. He specialised in a combination of International Strategy & Organisation and International Financial Management, and developed focussing on Purchasing and Supplier Management. Having studied for a semester at the 'ESC Reims' business school in France, he completed a seven month work placement at Xerox in Venray (the Netherlands) as a member of the global purchasing team. This period resulted in a master's thesis which dealt with supplier-vendor relationships and supplier repositioning strategies. This thesis was a joint winner of the 1999 NEVI thesis award. In June 1998 Ferrie was involved in a contract research project at the Institute for Purchasing and Supply Development at Technische Universiteit Eindhoven. This project focused on technological collaborations between multinational manufacturers and local suppliers in the south of the Netherlands. In October 1999, Ferrie started his PhD-project for the Eindhoven Centre for Innovation Studies (ECIS) at Eindhoven University in the Department of Technology Management. His thesis focused on the critical processes and conditions for effectively involving suppliers in product development. The research was carried out in collaboration with Océ Technologies and was supported by the Dutch Purchasing Association (NEVI). During his PhD Ferrie published several articles in scientific and popular journals and at international conferences. Ferrie has also been actively involved in developing a platform for connecting young professionals and students with an interest in purchasing and supplier management topics. This has resulted in the formation of Young Purchasing Professional organisations, both nationally and internationally. Ferrie's research interests are in the management of product and technology development, innovation, alliances, project management, purchasing and supply management, industrial networks, power/dependence and culture. Currently Ferrie van Echtelt is preparing publications of the results of the study and will use its expertise in practice.

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STELLINGEN

behorende bij het proefschrift

New product development: shifting suppliers into gear

van

Ferrie van Echtelt

1. Het vermogen om de expertise van leveranciers in productontwikkeling effectief en tijdig aan te wenden vereist tenminste besturing op samenwerkings-, project- en strategisch niveau. (Hoofdstuk 7)

2. Een eclectisch gevormd analytisch raamwerk is niet per definitie een samengeraapt bouwsel. (Hoofdstuk 3,9)

3. Een sterk project-gedreven organisatie is niet goed in staat structureel te profiteren van de kennis en ervaring van leveranciers. (Hoofdstuk 5,7)

4. Het vooraf kwalificeren van leveranciers voor betrokkenheid in toekomstige product ontwikkelingsprojecten werkt pas als hefboom indien vertegenwoordigers uit meerdere afdelingen daarin betrokken zijn. (Hoofdstuk 5,7)

5. Bij het niet halen van mijlpalen in ontwikkelingsprojecten wordt de zwarte piet vaak onterecht als eerste richting leverancier toegespeeld. In de meeste van deze gevallen, echter, is de opdrachtgever onvoldoende expliciet geweest over het verwachte eindresultaat en over het proces dat daar toe had moeten leiden. (Hoofdstuk 5)

6. Het tijdig demonstreren van tussentijdse resultaten en het goed onderhouden van contacten met de leverancier draagt in belangrijke mate bij aan het versterken van het vertrouwen in de samenwerking. (Hoofdstuk 5)

7. Het ontbreken van een gemeenschappelijk referentiekader tussen Inkoop, R&D en Productie afdelingen om te bepalen wat de gewenste inbreng van een toeleverancier in product ontwikkeling zou moeten zijn, is in belangrijke mate debet aan het falen van samenwerking met leveranciers in product ontwikkelingsprojecten. (Hoofdstuk 8)

8. Inkoop als multidisciplinair vakgebied zal zichzelf moeten vernieuwen. Dat betekent dat zij juist de randen moet verkennen en niet de kern.

9. De fascinatie voor een onderwerp is de brandstof voor een onderzoek(er).

10. De toekomst van de mensheid zal mede bepaald worden door de wijze waarop innovatie, acceptatie van en toegang tot nieuwe duurzame energiebronnen en technologieën gestalte zal krijgen.

11. Hoe ver je gaat in de reis tot een proefschrift heeft met afstand niets te maken, maar met de weg die de onderzoeker cognitief, innerlijk en emotioneel aflegt. (Naar Blöf-Omarm, 2003)

12. De afvalverwerkingscentrales zullen de stelling: 'Garbage in, Garbage out' terecht niet ondersteunen.

13. Actie-onderzoek is onmisbaar als onderzoeksmethode om een empirisch fenomeen werkelijk te begrijpen. (Naar Kurt Lewin 1890-1947)

14. Een gezonde dosis intuitie helpt onderzoek naar het verklaren van complexe empirische fenomenen eerder dan dat het schaadt.

15. De kwaliteit van onderzoek wordt ondermijnd doordat aantallen publicaties van een onderzoeker een doel op zich dreigen te worden.