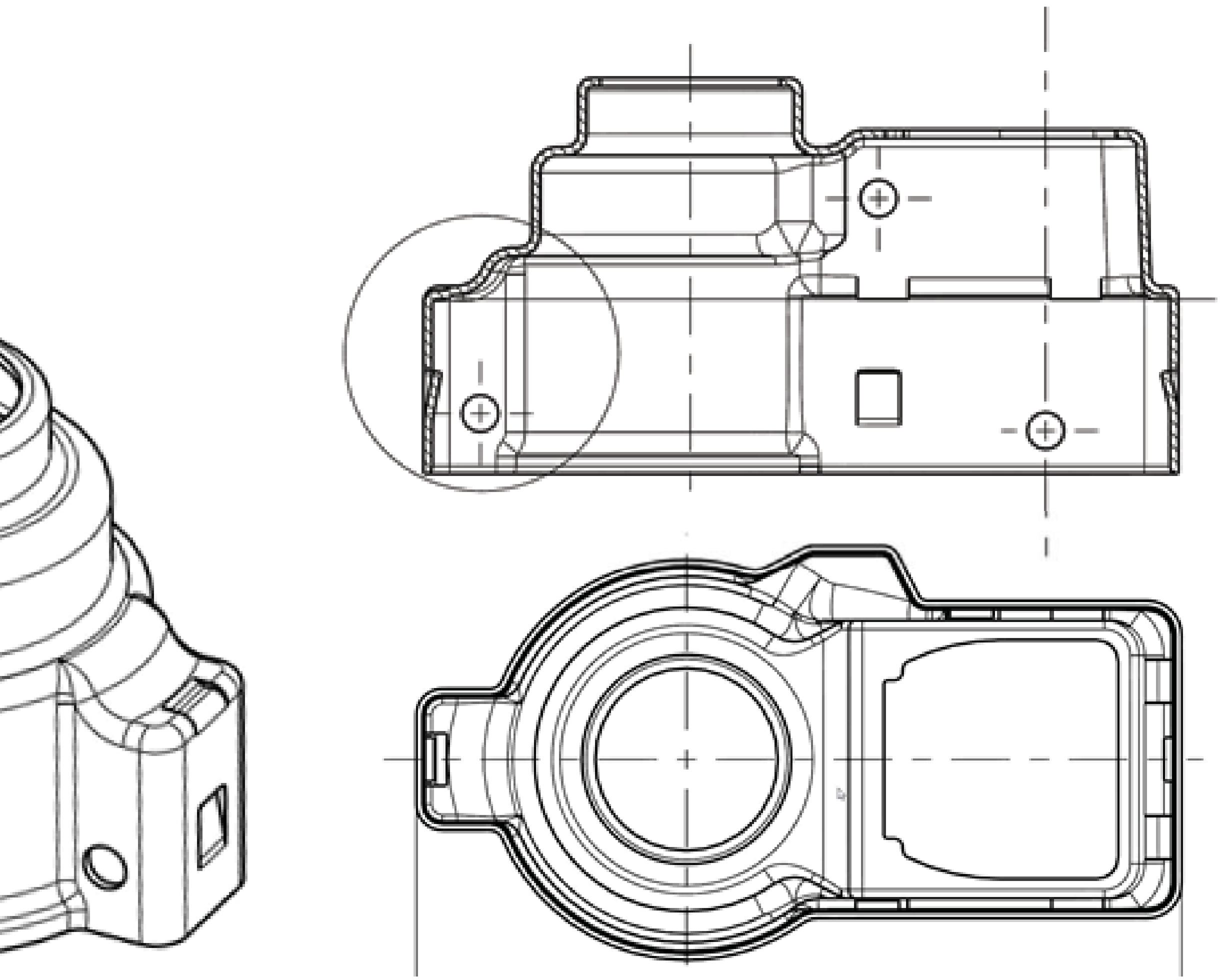
WHY DIDN'T THEY ASK THE SUPPLIER?

The Utilization of Supplier Information and Knowledge in the Fuzzy Front End of New Product Development

Jarmila A. **Kopecká**



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WHY DIDN'T THEY ASK THE SUPPLIER?

The Utilization of Supplier Information & Knowledge
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A fourth firm was found thanks to the social network of Bertus Naagen. I can't think of a finer example of how social ties work! Having four firms in the thesis was important in order to meet the requirement for the minimum number of firms that a multiple case study is expected to have.

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Jarmila Kopecká
Delft, August 2013

Chapter 1: **Setting the stage**

1. Introduction

The title of the present thesis is: *Why Didn't They Ask the Supplier? The Utilization of Supplier Information and Knowledge in the Fuzzy Front End of New Product Development.* The question in the title "Why Didn't They Ask the Supplier?" paraphrases Agatha Christie's detective novel "Why Didn't They Ask Evans?", published in the UK in 1934, and adapted for television in 1980. In the US, the book was published in 1935, under the title "The Boomerang Clue".

In this detective novel, the question "Why Didn't They Ask Evans?" represents the last words uttered by a man who fell off the cliffs at a seaside town in Wales. The last words were heard by Bobby Jones, the son of a local vicar, who found the dying man on the beach minutes before the man gave his final breath. Bobby decided to turn his hand to detective work. The reader (and Bobby) finds the answer about Evans in the last chapter of the book. Without going into the detail of the book's contents, suffice it to say, that Evans is the name of a parlour maid, Gladys Evans, who at her previous employer unknowingly witnessed a forged will. At the time of Bobby's investigation, Gladys began her new job at the vicarage, but Bobby was not aware of it.

The subtitle of the thesis, "the utilization of supplier information and knowledge in the fuzzy front end of new product development" suggests an answer to the question "Why didn't they ask the supplier?" The Evans' story shows that it helps when the party that grapples with questions, and the party that has answers to those questions, don't have an arm's length relationship with one another.

1.1 **Aims of the thesis**

The objective of the present thesis is to contribute to the development of theory on supplier involvement in new product development (NPD) by advancing understanding of the motives and conditions for the utilization of supplier information and knowledge in the fuzzy front end (FFE) of NPD. The empirical work in the thesis consists of four case studies (Chapters 4-7) and a Cross-case Analysis (Chapter 8). The multiple case study strategy has been chosen because it allows for analyzing and contributing rich data to the existing knowledge using perspectives from different contexts (Dul and Hak, 2008; Eisenhardt 1989; Yin, 2003). The overall structure of the thesis is shown in Figure 1.1 at the end of this chapter.

The term 'fuzzy front end' (FFE) was coined by Reinertsen (1985, 1999). The term refers to the activities that the firm undertakes prior to a NPD project. The FFE ends when the NPD project is launched, or rejected (Khurana and Rosenthal, 1998). What distinguishes the FFE from the other phases of NPD is the acknowledged high level of uncertainty and incomplete information about technical and market feasibility of the proposed product ideas, and about the firm's resource availability (Cooper, 2011; Frishammar et al., 2011; Hűsig and Kohn, 2003; Khurana and Rosenthal, 1997, 1998; Koen et al., 2001, 2002; Kijkuit and Van den Ende, 2007; Wagner 2012; Zhang and Doll, 2001). The FFE period is also the time when the first relationships with NPD supporters and partners from outside the firm, such as suppliers, start to develop. The NPD participants become acquainted with each other's capabilities (Kim and Wilemon, 2002; Wagner, 2012).

The research concerning supplier involvement in NPD spans three decades (Johnsen, 2009). By comparison, the research concerning supplier involvement in the FFE of NPD has received less attention. Even though the benefits of the input from suppliers during the FFE phase of customer's NPD have been recognized (Cooper, 2011; Khurana and Rosenthal, 1997; Kim and Wilemon, 2002), the FFE-NPD research primarily focused on the input from consumers, that is on the downstream value chain of the customer firm. The first empirical study about supplier integration in the FFE of NPD appeared in the April 2012 issue of Journal of Supply Chain Management (Wagner, 2012). Moreover, most of the previous research studied supplier involvement in NPD in relation to new product market performance.

The present thesis has a different objective, which is to investigate supplier involvement in the FFE of NPD from the perspective of the use and non-use of supplier information and knowledge. To this end, the thesis conceptualizes supplier firms as a source of information and knowledge located in the customer firm's upstream value chain. The utilization of supplier information and knowledge is conceptualized as an outcome of an information relationship between the provider and the seeker/user of supplier information and knowledge.

In its turn, the information relationship is conceptualized as a continuous, dynamic exchange process enabled by social ties between the seeker/user and the provider (Borgatti and Cross, 2003; Cross and Sproull, 2004). These conceptualizations lead to the following research problem:

> **Who are the providers and seekers/users of supplier information and knowledge in the FFE of NPD, and what leads to the formation of their information relationships, and ultimately, to the utilization of supplier information and knowledge?**

In the research problem statement, supplier information and supplier knowledge are used as a joint term. The two constituents of the joint term are, however, not identical. The definitions that follow are derived from the definitions of information and knowledge by Davenport and Prusak (1998), but are placed in the supplier context.

> *Supplier information consists of facts and ideas about supplier offerings (e.g., products, supplier support, etc.) and manufacturing technologies, and originates in the context of supplier firms and/or supplier markets.*

> *Supplier knowledge is an accumulation of expertise about supplier offerings (e.g., products, supplier support, etc.) and manufacturing technologies acquired and/or inferred through the experience and skills of human beings.*

Supplier knowledge can be tacit or explicit (Modi and Mabert, 2007; Wagner and Krause, 2009). The explicit knowledge (i.e., the know-what), is usually associated with the performance parameters of the supplier firm (e.g., the scrap ratios and product rejects during manufacturing), whereas the tacit supplier knowledge (i.e., the know-how and the know-why), concerns supplier capabilities, such as supplier design and production processes.

In the context of the present thesis, the human beings who handle supplier information and knowledge in the FFE of NPD are the individuals working in the functions of (Design) Engineering and Purchasing in the customer firm, and the individuals in the function of Sales Engineering in the supplier firm. As the (Design) Engineers, Purchasers and Sales Engineers exchange supplier information and knowledge with one another, they form pairs, or dyads, representing the information relationships at the micro-social level of the firm. Viewed from the sociological perspective, the micro-social level of the firm represents a level of analysis which enables an on-the-ground investigation of the patterns of (face-to-face) interactions of a small sample of informants representing specific individuals and groups in a specific social situation (Knorr-Cetina, 1981). In the present thesis, the micro-social level of the firm provides an opportunity to gain a fine grained picture of the exchanges of information and knowledge between the individuals involved in the FFE of NPD.

1.1.1 Dyadic information relationships

The present thesis investigates and compares the dyadic information relationship, and its outcome (i.e., the utilization of supplier information and knowledge), in the FFE of NPD in four firms. The exploration takes place through case studies (Chapters 4-7), each of which concludes with a number of Salient Issues that typify the dyadic information relationships under study. The identification of Salient Issues is preceded by the researcher's Reflective Comments which are presented in separate text-boxes. The Salient Issues form the input for the Cross-case Analysis in Chapter 8.

The first of the three dyadic information relationships under study is the dyad of the Sales Engineer of the supplier firm and the Purchaser of the customer firm. The Sales Engineer is the prime disseminator of supplier information, which is of two kinds, technical and commercial. Table 1.1 gives an illustration of the format and content of the disseminated supplier information in the customer firm. Table 1.1 also shows that while the intended recipient/user of the technical information in the customer firm is the (Design) Engineer, the intended recipient/user of the commercial information in the customer firm is the Purchaser. The exchange of information between the Sales Engineer and the Purchaser is routine, and concerns logistics and operational issues, such as product prices, order volumes, delivery times, and certification compliance.

The second dyadic information relationship is the dyad of the Sales Engineer of the supplier firm and the (Design) Engineers of the customer firm, and pertains to supplier's technical information in the form of product samples, prototypes, and such like. Sometimes, the information relationship with the (Design) Engineers leads to the Sales Engineer's participation in the FFE of NPD, and in co-designing customer's products. In such situations, the Sales Engineer adopts the work style of a knowledge worker (Darr, 2002, 2003, 2006), as he/she transfers the 'sticky' knowledge (Von Hippel, 1994; Szulanski, 2002) concerning the supplier manufacturing capabilities to the (Design) Engineers of the customer firm.

Lastly, the third dyadic information relationship is the dyad of the (Design) Engineers and the Purchasers of the customer firm. The content of the information exchange is determined by the degree to which the Purchasers participate in NPD projects. The information exchange concerns sourcing decisions with regard to the selection of suppliers, assessing supplier innovation capacity, monitoring supplier performance, the choice of product components and their design alternatives, and sharing the experience from past projects (Di Benedetto et al., 2003; Schiele et al., 2011; Schiele, 2012; Wynstra et al., 1999, 2000, 2003).

Table 1.1: Supplier information disseminated by the supplier's Sales Engineer in the customer firm.

Types of supplier information	Format	Content	Intended recipients or users
Technical	Face-to-face interactions in technical meetings; Supplier product documentation; Test reports; Supplier websites.	Product specifications; Product performance specifications; Product application instructions; Product samples; Drawings; Prototypes; Product/ process design parameters.	(Design) Engineers of the customer firm.
Commercial	Product catalogues; Supplier portals & e-procurement systems; Requests for proposal (RFP); Requests for quotation (RFQ); Contracts; Certification forms.	Product prices; Product quality; Delivery times; Order volumes; Quality control standards.	Purchasers of the customer firm.

1.1.2 Research Questions

The literature review in Chapter 2 will show that supplier involvement in NPD changed the roles of (Design) Engineers, Purchasers, and Sales Engineers, and brought new elements in their information relationship, and in the utilization of supplier information and knowledge. As far as could be established from the literature, the present thesis represents the first attempt to study supplier involvement in the FFE of NPD by focusing on the utilization of supplier information and knowledge, as perceived and experienced by the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering.

The supposition behind the present thesis is that the properties of information relationship between the provider and the user of supplier information and knowledge may be instrumental in whether or not the supplier information and knowledge in the FFE of NPD are utilized. The supplier firms, in the person of their Sales Engineers, represent the providers of information and knowledge. The (Design) Engineers and Purchasers of the customer firms represent the users. The present thesis seeks answers to questions concerning the content of the information relationships between these individuals. What kind of supplier information and knowledge is being sought and exchanged? How do such exchanges take place? The objective is to understand why some information relationships result in the utilization of supplier information and knowledge, while other do not. The definitive Research Questions that draw on the literature review will be formulated at the end of Chapter 2 after synthesizing the relevant literature.

1.2 Scientific relevance

Supplier involvement in the FFE of NPD is an under-researched topic. The literature review in Chapter 2 will uncover only one empirical study on supplier involvement in the FFE of NPD (Wagner, 2012). Previous research (Frishammar, 2005, Moenaert et al.,1995, and Zahay et al., 2004, 2011) that studied the information gathering activities in the FFE of NPD did not specifically address the potential of supplier information and knowledge as an external information source.

The practice of the FFE of NPD is not without problems. The 2003 PDMA (Product Development and Management Association) survey of Best Practices in NPD, the respondents of which were mostly large goods manufacturers in business-to business markets, reaffirmed that the FFE of NPD was one of the areas in need of improvement (Barczak et al., 2009). Earlier, the PDMA in its Tool Book for New Product Development (Koen et al, 2002: 29) described the FFE of NPD as the weakest area of the innovation process, and listed the weak points of the FFE of NPD as follows:

- FFE work is not structured, but is experimental, and often involves individuals instead of multifunctional teams;
- FFE work is so early that revenue expectations are uncertain, and it is often not possible to predict commercialization dates;
- Funding for FFE work is usually variable; and
- FFE work results in strengthening a concept, not achieving a planned milestone.

The present thesis aims to extend the research on the FFE of NPD, and supplier involvement in the FFE in particular, by addressing the first item in the PDMA list of the FFE weak points, namely that: "the FFE work is not structured, but is experimental, and often involves individuals instead of multifunctional teams" (Koen et al., 2002: 29).

This thesis seeks to find patterns and mechanisms in the FFE work by studying the information relationships of the FFE participants. To this end, individuals from three specific functional areas of customer and supplier firms were selected in order to study the what's, the how's and the why's/why not's of their respective information relationships.

1.2.3 Theoretical background

By addressing supplier involvement in the FFE of NPD at the micro-social level of the firm, the present thesis deviates from most of the research on supplier-customer relationships which uses the firm, or the NPD project, as the level of analysis. The choice of the micro-social level of analysis is given by the thesis' focus, which is to study the processes of exchange and utilization of supplier information and knowledge in the FFE of NPD, and which therefore necessitates to study the processes of exchange and utilization from the multiple perspectives of those who engage in these activities in their daily practice.

A further difference between the present thesis and the majority of research on supplier-customer relationship arises from the adopted theoretical approach. Modi and Mebert (2007) note, that most research on supplier-customer relationship explicitly or implicitly draws on the theory of transaction cost economics (TCE), developed by Oliver Williamson (1975). In contrast, the present thesis deploys the theory of "The Strength of Weak Ties" (Granovetter, 1973, 1982) as a theoretical background for understanding the information relationships in the FFE of NPD and the relationships' outcome, the utilization of supplier information and knowledge. The theory of Strength of Weak Ties holds that the social ties among the exchange partners act as conduits for the exchange of information and knowledge. The thesis also builds on the concept of embeddedness (Granovetter, 1985; Uzzi, 1996, 1997) which counters the assumed opportunistic behavior in business relations proclaimed by the TCE theory (Williamson, 1975) by presenting interpersonal relationships as a safeguard against misconduct in the exchange relationships. The safeguards include trust-building, reciprocity in information exchange, and cooperation between the exchange partners. Thus, the thesis contributes to the growing body of qualitative research that studies customer-supplier relationships (Galaskiewicz, 2011; Glicor and Autry, 2012; Van de Vijver et al., 2011), and supplier involvement in NPD (Bstieler, 2006; Lawson et al., 2009) from the perspective of interpersonal social relationships.

1.3 Practical relevance

Stake (1995, 2000) argues that case studies represent experiential knowledge. When the cases are written in sufficient descriptive narrative, they provide readers with a vicarious experience of the problem issues raised, and enable readers to draw or modify their own interpretations. The findings of case studies are not generalizable, but they relate to situations that happened, and that may happen again elsewhere. The learning effect of case studies for the practitioner lies in the recognizability of the problem issues that the case studies bring to light. The focus of case studies is on the particular: 1/ in finding patterns and interrelatedness in the studied events and activities in different contexts, and across diverse cases, and 2/ in finding a situation that is unique and we can learn from it; the "force of one single example" (Flyvbjerg, 2011).

The subject of the case studies in the present thesis - the utilization of supplier information and knowledge in the FFE of NPD - is a pertinent issue. In today's world of the multi-component and multi-technology products, the firms are obliged to seek knowledge from external sources. Supplier firms are one such external source. Roberts (2001) in his global benchmarking study covering largest R&D performing companies in North America, Europe and Japan reports that while in 1992 (the author's previous global survey) the percentage of partnerships with external technology sources in Europe was 22 %, in the year 2001 the percentage increased to 86%. The respective increase percentages for Japan were: from 35% to 84%, and for North America from 10% to 85%. The supplier firms represented 41% of partners in Japan, 38% in Europe, and 44% in North America. The other frequently used external source are the users. The literature shows that firms use these two external sources in their NPD projects in almost equal measure. A recent survey of 2, 527 firms in the Danish manufacturing industry (Knudsen and Mortensen, 2011) revealed that 56.9 % of the firms involved customers in NPD, and 61.5% of the firms involved suppliers.

The two external sources, however, differ in their application domains. Von Hippel (2006) compared supplier innovations and user innovations from the perspective of their knowledge contribution, and concluded that whereas the information and knowledge from users led to functionally (but not technically) novel products, the information and knowledge from suppliers resulted in improvements in convenience or reliability of existing products. Case studies by McEvily and Marcus (2005) found that Product Managers perceived supplier knowledge and information as more detailed, and more problem-specific. The Product Managers were better able to relate the supplier information and knowledge to their engineering problems. Moreover, the supplier firms were in a position to provide hands-on technical assistance in integrating new techniques. Similarly, Roy and Sivakumar (2010) point out that downstream feedback from users concentrated more on usage benefits that had first to be translated into design specifications, while upstream feedback from suppliers was directly related to manufacturing design and was more likely to focus on cost reduction.

Summing up, the use frequency and applicability of supplier information and knowledge in NPD have been established, but less is known about the dissemination of, search for, and the utilization of supplier information and knowledge by the individuals working in the FFE of NPD, which is the subject of the present thesis.

1.3.4 Managerial implications

From the managerial perspective, involving users in the FFE of NPD requires a different kind of management than when the firm involves supplier firms. Evaluating and selecting product ideas submitted by users is a structured activity of limited duration. Organizing focus groups with users, for example, can be done using prescribed evaluation techniques, such as SWIFT (Strength, Weaknesses, Individuality, Fixes, Transformation) recommended by the PDMA Tool Book 2 (Belliveau et al., 2004: 272-293). There is no long-term commitment needed between the firm and the users in order to engage in the exchange of information and knowledge.

In contrast, involving suppliers in the FFE of NPD means that the customer firm enters into an information relationship with a supplier firm which, however, may have its own goals and expectations concerning the relationship. The duration of the information relationships between the two firms is uncertain.

Moreover, the appreciation of supplier information and knowledge may not be equally shared by all the functions in the customer firm. A (Design) Engineer with a design responsibility values supplier information and knowledge differently than a Project Manager with a budget responsibility. So rather than managing the selection of product ideas, involving supplier firms in NPD entails managing the information relationships that generate the product ideas. Wilkinson (2008) gives an idea of the difficulty involved in managing relationships, when he states:

A relationship is a type of organization that takes on a life of its own to some extent; it is a living thing that is continually being and becoming (2008: 96).
A relationship is a pattern of behavior over time, not a pattern of behavior measured at a moment of time (2008: 9).

The four case studies and the Cross-case Analysis in the present thesis provide evidence about how the participating firms manage the information relationships between three professional groups: the (Design) Engineers, the Purchasers, and the Sales Engineers. The practitioners can learn from the experience of these individuals about the formation of their respective information relationships, and what hindered or helped them in the utilization of supplier information and knowledge in the FFE of NPD.

1.4 **Structure of the thesis**

The thesis is divided into nine chapters (and five appendices). The firms that participated in the case study are for confidentiality reasons disguised and referred to as Firms A, B, C, and D. Brief company profiles can be found in Appendix 5.

According to Stake (2006: 8), a case study is both a process of inquiry about the case and the product of that inquiry. The dual nature of case research is reflected in Figure 1.1 which outlines the process and the content of the present thesis.

The process is presented in the form of three parallel and interconnected columns of Define and Clarify, Execute and Analyze, and Synthesize and Evaluate so as to underline the iterative character of case research (Eisenhardt, 1989).

The content is shown in Chapter blocks. The Define and Clarify column introduces the reader to the subject of the thesis (Setting the Stage), and contains chapters describing the preparatory steps needed to start a thesis: the Literature Review to generate Research Questions, and the choices concerning Research Design and Methodology. The Execute and Analyze column contains chapters with the four case reports covering Within-case Analyses. Lastly, the Synthesize and Evaluate column presents the findings of the Cross-case Analysis, and contains a final chapter with the discussion pertaining to the Research Questions, the thesis' limitations, suggestions for further research, and the managerial implications.

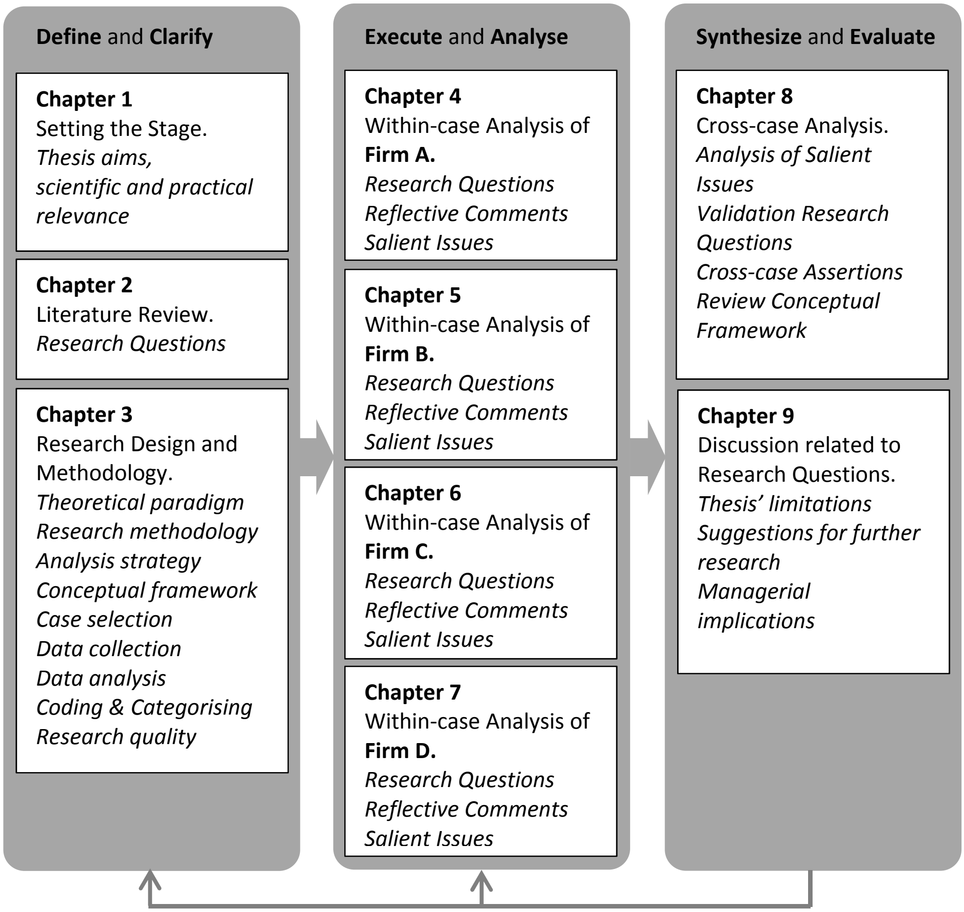

Figure 1.1: Structure of the thesis

Chapter 2: **Literature review**

2. Aims, methodology and structure of the literature review

Aims

The present literature review has two objectives. First, to identify the research fields in the scholarly literature that are related to the research problem and the emergent research questions introduced in Chapter 1, and to position the thesis within the identified fields. Secondly, to analyze and integrate previous research findings from the literature, with the aim to formulate definitive Research Questions.

Methodology

The followed methodology is a synthesis of a series of iterative searches performed at intervals throughout the period of the PhD study which started in 2006. An iterative search is a search in which search queries are continually adapted in order to accommodate the sharpening of the research focus, the diversity of search terms deployed in information sources, and the feedback obtained from the found literature.

The aim is to narrow down the scope of one's own research topic by identifying related fields of research, discerning the major themes and issues, in order to arrive at researchable research questions, while at the same time benefiting from the previous research. There are three related fields of research that served as departure points for the present literature review, namely: 1/Information search and knowledge transfer; 2/Supplier involvement in NPD; and 3/ Social networks.

Performing the literature searches involved the following activities:

- Setting up a Reference Manager database in order to archive the retrieved literature;
- Working with databases (JSTOR, Emerald, Wiley, Sage, Web of Science, and Scirus), and search engines Google and Scholar Google;

- Applying extensively the search methods of forward chaining (citations) and backward chaining (looking up the cited references);
- Focusing on core periodicals that publish regularly on the subject of NPD, Purchasing, Supply Chain Management, and Knowledge Management such as, for example, *Journal of Product Innovation Management, Industrial Marketing Management, Journal of Purchasing & Supply Management, Journal of Supply Chain Management, Journal of Operations & Production Management, Strategic Management Journal; MIS Quarterly, Journal of Knowledge Management, Academy of Management Review;*
- Limiting the selection of publications to those written in English;
- Targeting literature published after the year 2000. However, looking up cited references also resulted in identifying literature published prior the year 2000 (about 30% of the total references retrieved); and
- Following up on referrals received at the conferences of Ipsera (Purchasing & Supply Chain Management), EIASM-IPDMC (New Product Development Management), and IMP (Industrial Networks).
  (The selection criteria adopted throughout the literature searches were guided by the perceived relevance of the literature gauged by the researcher, rather than by the year of publication, or the ISI Impact Factor ranking of the journal.)

Structure

The scope and focus of the literature review is illustrated in Figure 2.1. The literature review is structured in five parts.

Part One of the literature review opens with the definitions of the four core constructs that are central to the subject of the present thesis, namely:

- new product development (NPD);
- the individuals in the new product development process;
- the fuzzy front end (FFE) of new product development;
- supplier information and knowledge.

Part Two discusses the literature concerning the information & knowledge exchange during supplier involvement in NPD (shown in the first three columns in Figure 2.1).

Part Three addresses the research related to the changing roles of (Design) Engineers, Purchasers, and Sales Engineers, resulting from supplier involvement in NPD (shown in the middle three columns in Fig, 2.1).Part Four reviews the literature pertaining to the social relations' role in the exchange of information and knowledge (shown in the last two columns in Figure 2.1). Part Five concludes with the literature review synthesis, and the formulation of three Research Questions. Parts Two, Three and Four contain interim Summaries and Conclusions, which highlight the relevance of the discussed literature to the present thesis.

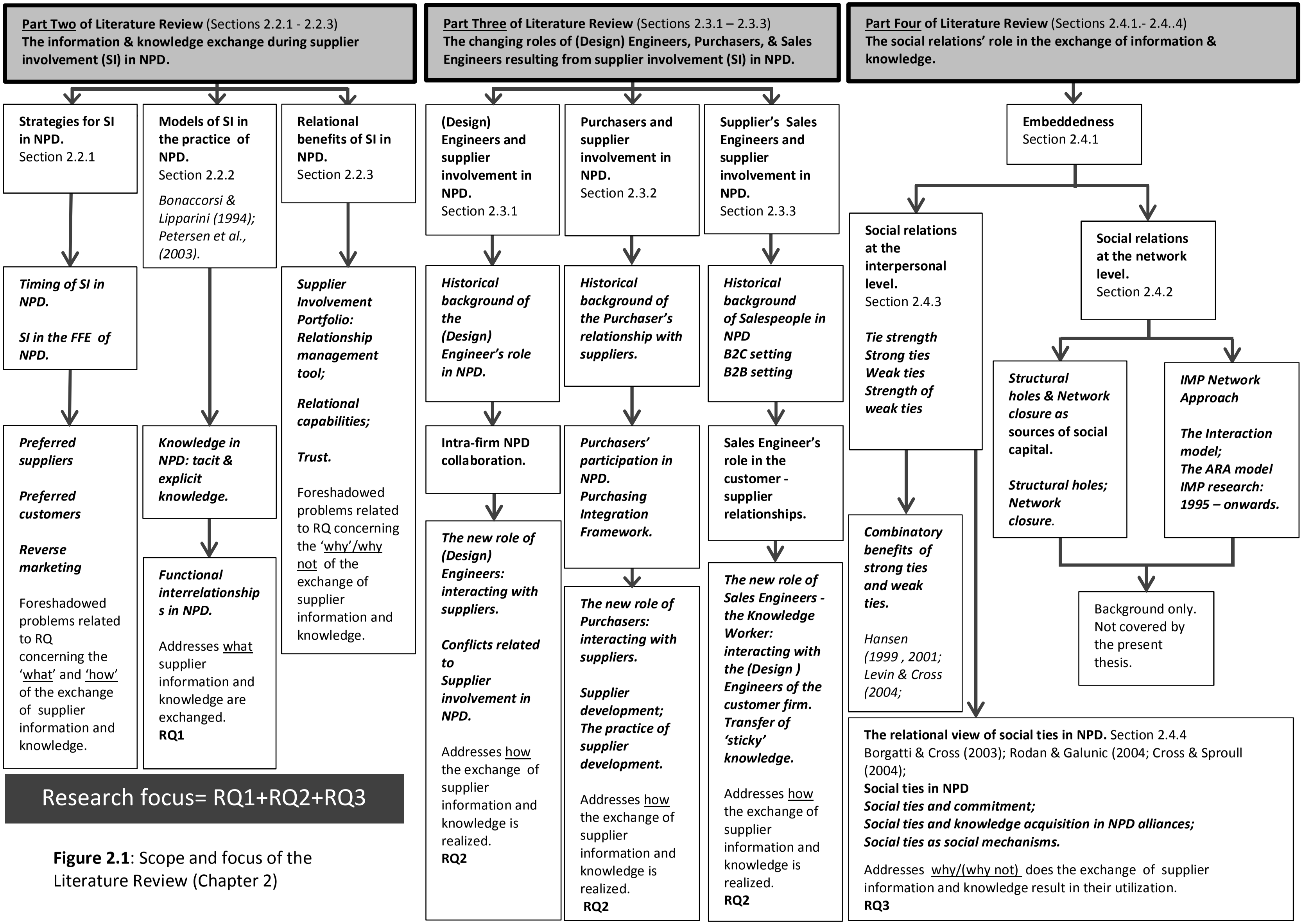

Figure 2.1: Scope and focus of the Literature Review (Chapter 2)

2.1 *Part One:* The core constructs' definitions and context

New Product Development (NPD)

Brown and Eisenhardt (1995) identified three research streams in the NPD literature: rational plan, communication web, and disciplined problem solving. The present thesis, with its focus on the exchange and utilization of supplier information and knowledge in the FFE of NPD, and with its treatment of NPD process as a social process involving individuals from diverse NPD functions and disciplines, can be classified as belonging to the 'communication web' research stream.

Frishammer and Ylinenpåå (2007: 442) called for more detail in the research on management of information in NPD: more data richness on how and why, and which information and knowledge was being used in NPD. They argued that since NPD was a process, we needed to know what was happening within the process in order to manage it better. The present thesis can be seen as a response to this call for more detail in the research. It focuses on the exchange and utilization of a specific type of information and knowledge; i.e., from supplier firms, in a specific phase of NPD; i.e. the fuzzy front end, involving individuals from specific functional areas; i.e., (Design) Engineering, Purchasing, and Sales Engineers.

NPD is in essence a knowledge-driven activity (Distanont et al., 2012; Frishammer, 2005; Griffin and Hauser, 1996; Kyriakopoulos and De Ruyter, 2003; Moenaert et al., 2000; Nonaka and Takeuchi, 1995). From the idea-generation stage of NPD to the launch stage, the new product represents embodied knowledge (Madhavan and Grover, 1992). Smith and Reinertsen (1998: 167) note that:

> *NPD is a process of gradually building up a body of information until it eventually provides a complete formula for manufacturing a new product.*

Similarly, Von Hippel (2006: 104) points out that:

> *Physical products are information products during the design stage.*

For the product designer, such information products during NPD would be prototypes or sketches of the intended product (Stompff, 2012).

Alternatively, the NPD process can be viewed as a process of matching the knowledge of customer requirements with the knowledge of the firm's engineering and manufacturing capabilities (Hong et al., 2004). Finding the fit between market needs and the firm's capabilities is the underlying premise of product effectiveness (Brown and Eisenhardt, 1995).

For the firm, the recombination and effective integration of knowledge and relationships of NPD participants, both from within and outside the firm, has long been recognized as a strategic resource (Brusoni, Prencipe and Pavitt, 2001; Dyer and Singh, 1998; Gadde and Snehota, 2000; Inkpen and Tsang, 2005; Knudsen, 2007).

In this sense, the process of NPD exemplifies the knowledge-based view (KBV) of the firm, which postulates that the firm is a knowledge processing institution (Grant, 1996, 2004; Leonard-Barton, 1992, 1995; Kogut and Zander, 1992; Nonaka and Takeuchi, 1995). However, the KBV of the firm is primarily concerned with the transfer of knowledge at the organizational level (Argote and Ingram, 2000), whereas the present thesis focuses on the level of individuals who are the main creators of knowledge and in whom much of the firm's knowledge resides (Argote et al., 2003; Foss et al., 2010).

Individuals in the NPD process

The present thesis conceptualizes the individuals in the NPD process as information channels through which information and knowledge flow, and from where information and knowledge originate. Information is data endowed with relevance and purpose; it is meant to affect the receiver's behavior and judgment (Davenport and Prusak, 1998). In contrast, knowledge is the result of human intellectual endeavor, as the next two definitions illustrate.

> *Knowledge is information validated by experience that has entered human belief systems as rules for guiding actions, and in the case of business, that has proved beneficial to firm performance (Song et al., 2005: 430).*

> *Knowledge derives from minds at work. Knowledge derives from information, as information derives from data. If information is to become knowledge, humans must do virtually all the work. This transformation happens through such 'C" words as: comparison, consequences, connections, conversation (Davenport and Prusak, 1998: 5-6).*

Both definitions underline the centrality of the human person, but the definitions differ in their interpretation of knowledge. The definition of Song et al. (2005) presents knowledge as 'static' in nature, proven, and embodied in rules. By comparison, the definition of Davenport and Prusak (1998) presents knowledge as a dynamic process. The latter view finds support from many scholars (Bhatt, 2001; Boisot, 1999; Jasimuddin et al., 2005; Nonaka and Takeuchi, 1995; Skyrme, 2001; Von Krogh and Grand, 2002) who posit that the conversion of information into knowledge is accomplished through social interaction between the individuals involved. Von Krogh and Grand (2002: 173) suggest that:

> *In order to fully understand knowledge creation in the firms, we need to unmask the processes of establishing knowledge-creating relationships as well.*

The role of individuals in information and knowledge exchange in the FFE of NPD has been studied by Reid and De Brentani (2004) who point out the differences between information searches for radical (innovations) and incremental innovations. In the case of incremental innovations, the information search is systematic and takes place within the functional areas of the firm.

By comparison, the information search at the FFE of radical innovations is unstructured and outward looking. The information search is initiated by boundary spanners who are on the lookout for emerging patterns outside the firm's environment and who disseminate their findings within the firm. Boundary spanners are individuals, employees of the firm, who develop external networks of relationships through which they relate the firm with elements in the external environment (Cousins et al., 2011; Reid and De Brentani, 2004, 2010; Frishammer amd Hörte, 2005). The 'technology entrepreneurs' that Procter and Gamble employs to scan and identify external innovation needs and to develop supplier networks would be an example of a boundary spanner (Witzeman et al., 2006).

In a similar vein, Spithoven et al. (2011) and Tracey (2004) argue that the overall absorptive capacity of firms (Cohen and Levinthal, 1990) depends on the individual absorptive capacities of the personnel to assimilate external and internal information and knowledge. This is particularly the case in smaller firms that have no R&D department (Spithoven et al., 2011), and therefore, depend on the capabilities of their employees to effectively monitor the developments in the firm's environment.

At the heart of the exchange of information and knowledge is the interpersonal relationship between the user and the provider of information and knowledge. The social dimension of the exchange of information is particularly strong in the FFE of NPD, where in the absence of formal procedures, interpersonal relationships become chief conduits for information and knowledge flows (Smulders, et al., 2007; Wang et al., 2005).

The relationship can be characterized by dimensions such as common knowledge base, shared experience, proximity, connectivity, length of relationship, frequency of interaction, reciprocity, and trust (Brown and Duguid, 2001; Granovetter, 1973; Hansen, 1999; Von Krogh and Grand, 2002). The lack or presence of these dimensions affects the individuals' information seeking and knowledge exchange behavior, and ultimately, the degree to which information and knowledge are utilized.

The individuals whose information behavior the present study has set out to investigate are active in the FFE of NPD and represent the functions of (Design) Engineering, Purchasing, and Sales Engineering.

Fuzzy Front End (FFE)

The FFE of NPD has been described as information intensive because it requires seeking, accessing and selecting different types of information from both internal and external sources (Frishammar, 2005; Frishammer and Ylinenpåå, 2007; Moenaert et al., 1995; Zahay et al., 2004, 2011; Zhang and Doll, 2001). As stated in Chapter 1, the potential value of supplier information and knowledge, as an external source in the FFE of NPD, has received little attention in the literature.

Khurana and Rosenthal (1998) define three phases of FFE:

- Pre-Phase Zero consists of preliminary opportunity identification, idea generation, and market and technology analysis. Khurana and Rosenthal (1998) emphasize the importance of understanding the link between the firm's product portfolio and the assessment of NPD opportunities;
- Phase Zero consists of identifying customer needs, market segments, and competitive situations; performing a technology evaluation of the firm's current capabilities and requirements and aligning them with the firm's technology and business plans; testing and evaluating product concepts;
- Phase One consists of feasibility and project planning, specifying the resources needed, identifying key risks and challenges, and the key project participants.

The four case studies in the present thesis show that the division of the FFE into phases is arbitrary. The case studies contained the elements of all three phases of the FFE, but the focus can be said to be on Phase Zero of the FFE because the majority of the case study informants were found active in this particular phase.

Previous NPD research has established that effective management of the idea generation process (Griffiths-Hermans and Grover, 2006) positively affects new product performance (Crawford and Di Benedetto, 2010; Langerak et al., 2004). However, the PDMA (Product Development and Management Association) surveys concerning NPD practices have repeatedly shown the FFE of NPD to be the weakest area of the NPD process, with shortcomings in storage and retrieval of generated ideas (Barczak et al., 2009; Koen et al., 2002). Williams et al. (2007) noted that there was an imbalance in the literature between information specifying 'what' needs to be done in the FFE of NPD and support for 'how' to tackle the FFE problems. Firms frequently had no mechanism in place that would react quickly to important developments in the marketplace, were lacking in process documentation, and had no effective mechanism for assessing the quality of a new product. In order to support the FFE process, Williams et al. (2007) developed and tested a reference model and architecture using an object-oriented analysis (OOA) methodology which enabled to bring together procedures, data, decisions, documents, resources and tools in a single unified configuration. In contrast, Nobelius and Trigg (2002) concluded from their case studies that given the diversity of FFE situations, striving for an optimal process in the FFE of NPD was futile, and that a formal model would actually stifle creativity.

Other authors highlighted the lack of employee involvement in the idea generation process. Firms lacked procedures for internal idea development (Montoya-Weiss and O'Driscoll, 2000), or the practiced leadership styles were not conducive to enhancing the employees' creativity (Hyypiä and Parjanen, 2013). Several authors (Khurana and Rosenthal, 1998; Wasti and Liker, 1999; Zien and Buckler, 1997) noted that due to the collaborative organizational culture of Japanese firms, the information sharing in the FFE of NPD was more common in the Japanese firms than in the US and European firms.

Hauser et al., (2006: 702) summed up the importance of a well-managed FFE of NPD as follows:

> *If in this stage [FFE], a firm can identify the best market opportunity, technological innovation, or a set of unmet customer needs, than the remaining steps become implementation.*

However, Khurana and Rosenthal (1998) found some major differences in approach to the FFE of NPD between the firms in consumer product industry and the firms in the OEM (original equipment manufacturing) industry. For example, the 'proximity' between the NPD firm and its customers or suppliers (i.e., the intensity of an ongoing dialog between the parties involved in the NPD process), was a feature more common among the firms in the OEM industry than among the firms in the consumer product industries. In their survey of 12 firms in the US, Europe and Japan, Khurana and Rosenthal (1998) noted that whereas in the consumer product firms, the product concepts at the end of the FFE had stable product definitions, in the OEM firms, the product concepts were frequently subject to modifications by customers. As a result, and as part of the ongoing dialog with customers, the OEM firms developed "design-related and organizational coping skills to help respond to the pressure from constant changes in product definitions" (Khurana and Rosenthal, 1998: 70).

This finding is consistent with the notion of Zhang and Doll (2001) that one should not confuse the cause of fuzziness with its effect. Thus, taking the example cited by Khurana and Rosenthal (1998: 70) while the OEM firm cannot control uncertainties surrounding technology development (the cause), it can control unclear definition of a product component (the effect) by forming a relationship with a supplier firm that has the necessary product technology (Tatikonda and Stock, 2003).

In the present thesis the participating firms all come from OEM industries. The findings of Khurana and Rosenthal (1998) are relevant because they link the practice of having open ended concepts in the FFE of NPD to the intensity of contacts between the customer and supplier firms. As stated earlier in Chapter 1, the present thesis proposes to investigate the FFE of NPD from the perspective of information relationships between the individuals from both customer and supplier firms. The negotiability of product concepts is expected to be influenced by the type and ways in which supplier information and knowledge are exchanged.

Supplier information and knowledge

Supplier information and knowledge is a joint term; there is a degree of overlap between the terms. The definitions, as applied throughout the present thesis, were given in Chapter 1.

Using supplier information and knowledge by involving supplier firms in NPD has its risks and benefits as the next paragraphs illustrate.

The leakage of proprietary information and technical skills is the most frequently mentioned risk of collaborative NPD (Ettlie and Pavlou, 2006; Littler et al., 1995;

McIvor and Humphreys, 2004; Takeishi, 2002). Becker and Zirpoli (2003) in their case study of product development at Fiat Auto, addressed the issue of knowledge hollowing-out and knowledge integration that Fiat Auto experienced in the course of outsourcing the development of product parts to suppliers. In the Fiat case, the collaboration with suppliers has not been all positive. Becker and Zirpoli (2003) observe that knowledge in product development on its own is not enough unless it is backed up by knowing when and how to put the knowledge to use. Koufteros et al. (2005) take a similar standpoint when they report that giving more product development responsibilities to suppliers could have negative effect on the ability of the customer firm to offer new products and features. The customer firm has no longer the knowledge that is gained through learning by doing.

Takeishi (2002) acknowledges the problem of developing and maintaining knowledge about outsourced parts, and proposes the concept of 'knowledge partitioning' with which to define the knowledge boundaries of the firm. For regular outsourcing projects, involving product parts for which the customer firm lacks production capacity, the customer firm should have a higher level of architectural knowledge (i.e., knowledge about the overall composition of the product, how the components form the whole). In contrast, for outsourcing projects involving new technology, the customer firm should have a higher level of component-specific knowledge, thus extending its knowledge boundaries towards the production knowledge boundaries of the supplier firm. A certain overlap in the knowledge base of the supplier firm and customer firm is needed to facilitate the exchange of information and knowledge between the two firms, and to enable the customer firm to effectively control the quality of the outsourced components.

The interviews with R&D Directors and Project Managers (Wagner and Hoegl, 2006) show that the Management is all too aware of the risks associated with knowledge transfer in the course of supplier involvement in NPD. The interviewees repeatedly stressed that only the supplier firms with which the customer firm had partnership-like relationships were invited to participate in early development projects, thus echoing the view of Dowlatshahi (2000) that exchanging product sensitive information and knowledge implied confidential partnerships, and that such partnerships couldn't be developed and maintained, if the relationship was short-term, limited, or a one-time event only.

To mitigate the risks of outsourcing, and to facilitate the knowledge exchange between supplier and customer firms, Azadegan et al. (2008) propose a relational construct of 'the ratio of tangibles and intangibles in supplier responsibility' which the customer firm can use to align its needs with the supplier capabilities. In outsourcing for tangible resources, the firm relies on the supplier for materials, components, assembling parts, and such like, whereas outsourcing for intangible resources involves using supplier skills, expertise, or intellectual property for the firm's product design and NPD. In practice, outsourcing is a combination of both tangible and intangible resources.

The idea behind the proposed tangibility ratio is to help firms in supplier selection. Low ratio value corresponds to the tasks concerning outsourcing of intangibles, whereas high value ratio corresponds to the tasks related to outsourcing of tangibles.

Azadegan et al. (2008) use the tangibility ratio to develop a conceptual model which further enables the customer firm to select suppliers according to supplier innovativeness; i.e., to select supplier firms through which the customer firm gains access to new knowledge, and from which the customer firm can expect the intangible benefits of learning.

Tatikonda and Stock (2003) offer a different perspective on the benefits of supplier information and knowledge in NPD when they describe the NPD process as a series of multiple technology transfers, varying in timing and the nature of technology transferred. Tatikonda and Stock (2003) make a distinction between two kinds of upstream supply chains, each producing a different type of knowledge. One, the technology supply chain which produces knowledge on single product technology, the transfer of which is occasional, and takes place in the FFE of NPD. The other, the component supply chain which produces knowledge concerning the manufacture of customer specified components.

Applied to the context of the present thesis, the exchange of knowledge from the component supply chain concerns routine contacts between Purchasers of the customer firm and Sales Engineers of the supplier firm, whereas the exchange of knowledge from the technology supply chain would involve (Design) Engineers of both firms, mediated by the Sales Engineer of the supplier firm. The conceptual model of Tatikonda and Stock (2003) depicts the transfer of product technology as a dyadic process between the provider and the recipient. The transfer of product technology is effective when there is a fit between the technology uncertainty of technology to be transferred and the interaction between the provider and the recipient. In other words, the information relationship between the provider and the recipient plays an important role in the transfer of product technology. The present thesis focuses on the information relationships between (Design) Engineers, Purchasers and Sales Engineers and investigates the ways how the dyadic information relationships work in the context of the FFE of NPD.

2.2 *Part Two:* The Information and knowledge exchange during supplier involvement (SI) in NPD

The main themes of Part Two of the literature review (the first three columns in Figure 2.1) are:

- Strategies for Supplier Involvement (SI) in NPD in Section 2.2.1;
- Models of SI in the practice of NPD in Section 2.2.2; and
- Relational Benefits of SI in NPD in Section 2.2.3.

2.2.1 Strategies for supplier involvement in NPD

A frequently cited research on supplier involvement in NPD has been a three year world-wide survey carried out by Dr. M. Monczka and colleagues from the Michigan State University (MSU) resulting in a book entitled "New Product Development: Strategies for Supplier Integration (Monczka et al., 2000). The MSU survey findings served to: 1/ develop an explanatory model describing factors contributing to successful integration of suppliers in NPD; 2/ identify strategies and practices in use; 3/ develop implementation guidelines; and 4/ provide case vignettes.

The MSU classifications scheme shown in Figure 2.2 illustrates the diversity in supplier involvement in NPD as a row of boxes. The scheme uses the term 'buyer firm' to refer to customer firms. Since the present thesis has adopted the term 'customer firm', the following description of the classifications scheme will substitute the term 'buyer firm' for that of 'customer firm'. The classifications scheme in Figure 2.2 starts from the box 'none' (*i.e.*, there is no involvement of supplier firms in the customer's NPD). Suppliers' products are 'made to print', which means that supplier firms follow the product specifications provided by the customer firm. The supplier and customer firms have an arm's length relationship with one another, governed by price considerations (Requests for Quotation). The classifications scheme then follows on to the 'white box' which indicates an informal supplier integration; one in which the customer firm informally consults the supplier firm.

The consultations are driven by problems encountered in the customer developed product specification, and concern mature/stable technology. Although Monczka et al. (2002) don't use the term 'fuzzy front end', the 'white box' could be so interpreted because it represents the initial steps in exchanging information and knowledge between the customer and supplier firm.

None	White Box	Grey Box	Black Box
No supplier involvement. Supplier 'makes to print'. Request for Quotation (RFQ) driven. Many potential suppliers. Arms-distance relationships	Informal supplier integration Buyer consults with supplier on buyer's design. Problem driven. Mature/stable technology. Buyer developed specifications.	Formalized supplier integration. Joint buyer and supplier development activities. Strategy driven. Key but noncore technology Jointly developed classifications.	Design primarily supplier controlled based on long-term technology strategy. Strategy driven. Key and perhaps core technology. Jointly developed requirements.

Increasing Supplier Responsibility →

Figure 2.2: Spectrum of Supplier Integration (Monczka et al., 2000: 6) (Reprinted with permission from ***New Product Development: Strategies for Supplier Integration*** ©2000. American Society for Quality. (No further distribution allowed without permission).

The next stage in the classifications scheme is the ‘grey box’ which marks the period in which there are formalized agreements between the customer and supplier firm, pertaining to the strategy driven joint NPD activities, and involving key but noncore technology of the customer firm.

The final stage of supplier integration is the ‘black box’ describing the situations in which customer firms adopt a long-term technology strategy by outsourcing the design and engineering of a product part to supplier firms, which then take the primary responsibility for the product part. The product requirements are developed jointly and may involve the customer’s core technology.

What makes the MSU survey particularly interesting for the present thesis is the fact that the MSU survey focused only on the ‘grey box’ and the ‘black box’ type of supplier integration. The ‘white box’ type of integration, in which the customer firm informally seeks information and knowledge from the supplier firm, and which is closest to the subject of the present thesis, was excluded from the MSU survey, and the authors (Monczka et al., 2000:6) don’t provide reasons for this decision. A plausible explanation could be that the initial informal inquiries with supplier firms begin at the level of the firm’s employees, whereas the intended use of the classifications scheme is to describe supplier involvement at the strategic and project level of the firm. The informal inquiries could, for example, be made by a (Design) Engineer of the customer firm when he/she discusses an engineering problem with a Sales Engineer and/or a (Design) Engineer of the supplier firm, and when such incidental exchanges of information and knowledge do not automatically commit either party to a NPD project. The focus of the present thesis is on the formation of this kind of information relationships, involving individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering who exchange and utilize supplier information and knowledge in the FFE of NPD.

Timing of supplier involvement

Although Monczka et al. (2000) did not include the ‘white box’ supplier integration in the MSU survey, the ‘white-box’ integration is nevertheless shown in the spectrum of supplier involvement timing, illustrated in Figure 2.3.

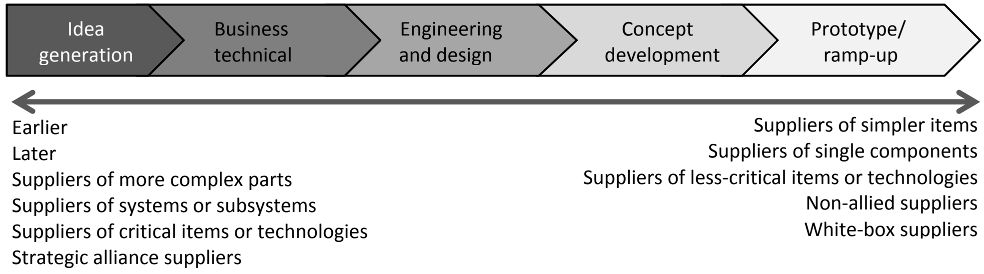

Figure 2.3 Timing of Supplier Integration (Monczka et al., 2000: 9)(Reprinted with permission from ***New Product Development: Strategies for Supplier Integration*** ©2000. American Society for Quality. No further distribution allowed without permission)

The 'white box' is positioned at the prototype/ramp-up stage of NPD, and is considered useful in the development of simpler; i.e., incremental products. Finding the right time for supplier involvement in NPD is a much discussed topic in the literature.

Several authors hold different views to Monczka et al. (2000), or propose additional stipulations regarding the timing, and the contribution that suppliers make. (The terms 'supplier integration' and 'supplier involvement' are used interchangeably in the literature). Song and Thieme (2009) investigated the contribution of suppliers in gathering market information, and concluded that the supplier contribution varied with the type of innovation (radical vs. incremental) and the stage of the NPD process (predesign versus commercialization). Song and Thieme (2009: 53) point out that:

> *Although the current practice suggests that teams allocate fewer resources to gathering market intelligence through their suppliers during predesign activities in incremental innovations projects compared with radical innovation projects; the findings [of our research] suggest that they should do the opposite. […].*

Thus, market information gathered via suppliers in the predesign stage had a greater impact on the success in incremental innovation compared with radical innovation. This finding is consistent with the research of Von Hippel (2006).

De Toni and Nassimbeni (2001) reported similar findings. Their case study (which makes no distinction between incremental and radical innovations, but involves a high technology make-to-order firm where supplier involvement is a critical factor for NPD success) concludes that the customer firm should entrust the scanning of technology markets to suppliers. De Toni and Nassimbeni (2001) view suppliers as 'gatekeepers' (Allen, 1977) who can bring the customer firm into contact with innovative ideas in the supplier's field of expertise.

Wynstra and Ten Pierick (2000) in their Supplier Involvement Portfolio emphasized that decisions about timing should also include considerations concerning the appropriate form of supplier involvement as the applicability of supplier expertise could vary both across the projects but also within the stages of the NPD process.

Koufteros et al. (2005: 102) distinguished between two types of supplier integration. First, supplier product integrations (Suppliers take responsibility for product engineering activities that they carry out on behalf of their customers. Both the supplier firm and the customer's internal NPD team members have a clear and consistent understanding of what they expect from the NPD project). Second, supplier process integrations (Suppliers work alongside the customer's engineers to jointly design the product with the aim to effectively integrate the supplier's manufacturing process with the customer's design. Suppliers provide information about alternatives with regard to material specification, availability, cost, and scheduling).

Koufteros et al. (2005: 100) observed that making the distinction between the two types of supplier integration was important as firms might integrate suppliers from a process and/or product point of view. Koufteros et al. (2005) surmised that it was the absence of this distinction in the research that could explain the differential findings in the literature on the benefits of supplier integration.

Further research by Koufteros et al. (2007) compared the 'grey box' and 'black box' type of supplier integration for their timing and their respective effect on product innovation in 157 small and large US firms. In both small and large firms, supplier integration in NPD resulted from a decision to reduce the firm's supply base. The study found that large firms engaged more in supplier 'gray box' integration than did small firms. With regard to the effect of supplier integration on product innovation, only 'gray box' integration manifested statistically significant effects on product innovation, whereas the effects of 'black box' integration were negligible. Koufteros et al. (2007) ascribed this result to the relative newness of 'black box' supplier integration in the US.

The research on the benefits of supplier involvement in NPD is inconclusive, with mixed results. Several scholars (e.g., Eisenhardt and Tabrizi, 1995; McGinnis and Vallopra, 1999; Primo and Amundson, 2002; Song et al., 2006) report that involving suppliers can, in certain situations, actually delay the NPD process. However, this literature falls outside the scope of the present thesis because it focuses on supplier involvement as an influencing factor on the new product market performance, and not on supplier involvement as a means to access supplier information and knowledge in the FFE of NPD.

Supplier involvement in the FFE of NPD

The first ever empirical study of the supplier involvement in the FFE of NPD (Wagner, 2012) investigated the FFE in 67 NPD projects in 16 firms (representing automotive, machine tools, household appliances, and electronics industries). The firms were purposefully selected because they were active in R&D and innovation.

The research model hypothesized that integration of suppliers in the FFE of NPD will result in higher NPD project performance, and that this impact will be moderated by three factors, namely:

- the absorptive capacity of the customer firm (i.e., the customer firm's ability to exploit supplier-specific knowledge);
- the relationship-specific assets (e.g. equipment systems, or other investments that make the customer firm dependent on the supplier firm); and
- integration of suppliers in the later stages of NPD. When a customer firm integrates a supplier firm in the later stages of the NPD process (e.g., the supplier firm is to design a product jointly with the customer firm), the customer firm can still benefit from supplier ideas, knowledge and capabilities that the supplier firm might have provided earlier had it been integrated in the FFE of NPD.

The main research hypothesis that the integration of suppliers in the FFE will have a positive effect on the NPD project performance was strongly supported by the data. The hypothesized moderating effect of absorptive capacity was not supported. Higher levels of supplier-specific absorptive capacity of the customer firm did not have a positive effect on the supplier integration in the customer's NPD-FFE.

The hypothesized moderating effects of the relationship-specific assets were significant. The positive effect of supplier integration in the FFE of NPD on the NPD project performance was weaker at higher level of specific assets.

Following the theory of transaction cost economics, TCE (Williamson, 1975), the study argues that in cases when the customer firm is wholly dependent on specific assets of the supplier firm, such as equipment or materials (as in the case by De Toni and Nassimbeni, 2001, cited above), involving such suppliers in the FFE leads to an increase in the transaction costs, and therefore, makes the supplier contribution smaller. The increase in transaction costs results from the need for extra contractual negotiations and monitoring in order to safeguard the exchange of critical NPD knowledge that characterizes the FFE stage. The study notes that supplier involvement in the FFE of NPD is more effective when the supplier assets are low, and the exchange of information and knowledge in the FFE is unhindered by concerns about proprietary knowledge. Wagner (2012) further suggests that the decisions on the timing of supplier involvement should include the evaluation of supplier asset specificity.

The hypothesized moderating effect of supplier integration in the later stages was significant. The positive effect of supplier integration in the FFE of NPD on the NPD project performance was weaker at higher levels of supplier integration than in the later stages of the NPD process. The supplier integration in the later stages of NPD, as it were, 'switched off' the benefits of supplier involvement in the FFE. The implication of this finding is that the decisions about supplier involvement in the FFE of NPD should consider the desirability of having supplier input sooner in the NPD process rather than later. Moreover, the study found that the input of suppliers in the FFE of NPD did not always produce equally positive results.

Table 2.1 summarizes the findings: it shows the items on which the suppliers' input was sought and how suppliers 'scored' on each item. The study found that suppliers were only minimally effective in idea generation. In contrast, their contribution was significant when evaluating commercial ideas because they could make suggestions on how to make a product less costly to manufacture, or easier to assemble. The conclusion of the study is that the firms should plan supplier involvement in the FFE of NPD strategically; i.e., not spend resources on involving suppliers in activities in which supplier contribution is minimal, or even negative.

The Wagner's research represents the first systematic attempt to empirically investigate supplier involvement in the FFE of NPD. The study approaches the exchange of information and knowledge between the customer and supplier firm from the perspective of the TCE theory (Williamson, 1975).

The study's recommendation to consider the supplier asset specificity prior to involving suppliers in the FFE of NPD is consistent with the TCE theory as well as with the chosen level of analysis (the NPD project). In doing so, however, the study detracts attention from the practice of daily use of supplier information and knowledge by the individuals in the FFE of NPD. By comparison, the present thesis approaches the exchange and utilization of supplier information and knowledge in the FFE of NPD from the perspective of social relationships (Granovetter, 1975, 1982; Hansen, 1999; Levin and Cross, 2004) between the individuals representing the functions found operating in the FFE of NPD.

Table 2.1 The suppliers' input in the FFE of NPD (Wagner, 2012)

The FFE items on which information was sought	Suppliers' effect
Idea generation	minimal
Commercial idea evaluation	significant
Technical idea evaluation	negative
Preliminary market study	negative
Product definition	significant
Definition of specifications	minimal
Concept development	significant
Commercial concept evaluation	negative
Technical concept evaluation	significant

Preferred supplier or preferred customer?

The concepts of 'preferred supplier' and 'preferred customer' represent two different strategies in the customer-supplier relationship, but with one single objective, namely: to leverage supplier competence and capability, and thereby gaining a competitive advantage. The next sections will discuss both concepts in turn, followed by a section on the concept of reverse marketing from which the strategies of preferred supplier and preferred customer originate.

Preferred suppliers

The concept of 'preferred supplier' reflects the trend among the customer firms to reduce their supply base to a small number of suppliers in order to optimize (rationalize) the supply base complexity and reduce administrative costs (Choi and Krause, 2006). Often, reductions in the number of suppliers represent a cut of more than 50 percent (Biemans and Brand, 1995; Ulaga and Eggert, 2006). The remaining suppliers are 'preferred' because their technological knowledge and products complement the technology base of the customer firm. The technology base is a portfolio of the firm's assets for innovation (Christensen, 1996: 111).

With the consolidation of the supplier base, suppliers need to differentiate themselves from their competition on more than price and product quality alone. Increasingly, customer firms are guided in their choice of suppliers not only by concerns of supply base optimizations but also by the supplier's ability to add value to the customer-supplier relationship (Koufteros et al., 2007).

Halley and Nollet (2002:41) give the following definition of a preferred supplier:

> *The preferred supplier is better able to constantly offer the order giver a renewed product performance at an advantageous price. It is also a supplier with whom more intensive business takes place (e.g., medium-and long-term agreements, reciprocal trust, growth in purchases, standardization and simplification of procedures, etc.), while promoting increased coordination/integration of skills in order to create win-win situations and sharing the risks (e.g., exchange of technical and information systems expertise, joint development of new products, joint improvement of processes, profit sharing, etc.).*

The customer firm accords the status of preferred supplier following a selection process led by the Purchasing department that presides over the firm's Commodity/Sourcing Committee. Ideally, the functions of Engineering, Quality Control, and R&D are all represented on the committee. Monczka et al. (2000: 112) underline the importance of securing a broad base support for the selection of preferred suppliers: "Commodity team consensus, particularly between Engineering and Purchasing, is a critical part in this process". Fliess and Becker (2006) express similar views when they stress the need for collaboration between the technical and commercial departments of the firm during the supplier selection.

Research by Ulaga and Eggert (2006) found that Purchasing managers in the US identified supplier service support and personal interaction as core differentiators, followed by supplier know-how, and a supplier's ability to improve time to market of customer's products. Having the status of a preferred supplier brought considerable advantages to the supplier firm. On average, preferred suppliers secured 73.3% of customer's order volumes. They worked in joint teams with the customer firm to solve quality problems which, in turn, enabled them to accumulate knowledge about the customer's operations, and placed them in a better position to compete for new orders. The status of preferred supplier and supplier know-how were found to be mutually reinforcing (Ulaga and Eggert, 2006).

Wynstra et al. (2003) defined three areas of responsibility for Purchasing, all of which involve exchanging information with and about suppliers:

- Targeting suppliers for collaboration. Purchasing narrows down the pool of potential suppliers from which to select preferred suppliers;
- Coordinating & timing the collaboration. Coordinating means that the customer firm "closely watches and analyzes the capabilities of the supplier and 'constructs' a new product around the components or materials of the supplier" (Wynstra et al., 2003: 74). Timing the collaboration refers to the need to synchronize the customer firm's introduction of new products, or new product design, with the production capabilities of the supplier; and
  'Motivating' suppliers to collaborate. Persuading suppliers to collaborate in NPD.

Wynstra et al. (2003) note that the activity of 'motivating' is often underestimated. Practitioners and researchers usually see customer firms as being more powerful than suppliers, assuming that the customer firms can 'demand' supplier collaboration. The evidence from the case studies of Wynstra et al. (2003) indicates that this is not always true. On the contrary, motivating suppliers to take part in collaborative NPD, often necessitates that the customer firm first becomes the supplier's 'preferred customer'.

Preferred customers

The concept of 'preferred customer' reflects the scarcity of innovative suppliers, and consequently, the scarcity of potential partners for collaborative NPD (Schiele, 2012). This is, for example, the case in the automotive industry where a wave of acquisitions and mergers in the supply chain in the 1990's resulted in a small number of mega-suppliers with global presence (Sturgeon et al. 2008; Veloso and Kumar, 2002). The demand for innovative suppliers and collaborative relationships can also be ascribed to the trend of customer firms to outsource parts of their NPD engineering to suppliers (Trent, 2005).

The 'preferred customer' concept holds that it is no longer the customer firm but the supplier firm that decides whether or not the NPD collaboration between the customer and supplier firm takes place. Schiele (2012) defines a 'preferred customer' as a firm that enjoys preferential allocation of supplier resources. The supplier resources can also include human resources in the form of temporarily placement of supplier's Engineers to work at the site of the customer firm.Thus, in order to ensure the willingness of the supplier firm to share its knowledge and skills, the customer firm must be perceived by the supplier firm as attractive (Hūttinger et al., 2012; Schiele et al., 2010, 2011, 2012), and be 'rewarded' with the status of a 'preferred customer'.

What makes a firm attractive? The concept of attractiveness of the firm dates back to purchasing portfolio management (Olsen and Ellram, 1997) when a firm evaluated the attractiveness of suppliers along several business criteria, such as financial and economic record, technical and performance factors, etc., with the aim to define the firm's supply strategy. Later, the concept of attractiveness of the firm was used in the research that focused on the interdependence between the trading partners, to explain the role of trust and commitment in forming customer-supplier relationships (Ellegaard et al., 2003; Ellegaard and Ritter, 2006; Mortensen at al., 2008).

Bonner and Calantone (2003) adopted the term 'attentiveness' rather than attractiveness, when they studied the antecedents of obtaining a status of the supplier's 'favorable customer'. An attentive customer manifests a favorable purchase behavior by purchasing the supplier's products frequently, steadily, and by pursuing cost reducing activities, such as developing routine purchase procedures, giving advanced notice of volume, timing, and delivery requirements.

Bonner and Calantone (2003) found that customer attentiveness had a stronger positive influence on the customer's chances of becoming a favorable customer than did the relationship length, or relationship dependence.

Hald et al. (2008) in their conceptual model of attraction in buyer-supplier relationship proposed three components of attraction:

- the attracted party's expected value of being associated with the other party;
- the attracted party's perceived trust in the other; and
- the attracted party's perceived dependence on the other party.

These components - value, trust and dependence - draw the dyadic parties together, or push them apart. Hald et al. (2008: 568) point out that since buyer-supplier attraction is built on the perception of many different individuals who work in different functions in each of the companies forming a dyad, there could be conflicting perceptions of the business partner's attractiveness. In order to bring unity in the diversity of perceptions, Hald et al. (2008) suggest that the firm's Management should use the mechanism of institutionalization whereby the three components - value, trust and dependence - are made part of the firm's vision and culture, and thus become embedded in customer-supplier relationships.

Reverse marketing

The practice of firms to leverage supplier competence and capability through developing close relationships with suppliers, and thereby gaining a competitive advantage, can be traced back to the concept of 'reverse marketing'.

The concept of 'reverse marketing' was introduced by Leenders and Blenkhorn (1988), when they questioned the suitability of the marketing concept for industrial marketing. Under the marketing concept, customer firms are expected to rely on suppliers whether or not suppliers respond to, or anticipate customer needs.

Under the concept of 'reverse marketing', the customer firm takes the initiative. The roles between customer and supplier firms become reversed. The customer firm sets out to persuade the supplier firm to provide products that meet the specifications of the customer firm, or alternatively, to supply a product for which the customer firm determines the best solution (Biemans and Brand, 1999). In reverse marketing, customer firms seek suppliers who are willing to share the ups and downs of a long-term business relationship (Blenkhorn and Banting, 1991).

The major player in reverse marketing is the Purchasing department of the customer firm: Purchasers identify potential suppliers and offer suitable supplier firms a proposal for long-term collaboration (Biemans and Strand, 1995). Through these activities Purchasers accumulate knowledge about the supply market and, as a result, become an important information source within the firm.

Summary Section 2.2.1

The concepts of 'preferred suppliers', 'preferred customers', and 'reverse marketing' represent strategies for closer cooperation between the customer and supplier firm. Supplier involvement in NPD is a particular form of cooperation, which the customer firm pursues in order to leverage supplier knowledge and capability for its future competitive advantage.

In the literature overview shown in Figure 2.1, all three concepts (the 1st column), have been earmarked as 'foreshadowed problems' related to the Research Questions (RQ) concerning the 'what' and the 'how' of the exchanges of information and knowledge.

The term 'foreshadowed problem' has been used by Robert E. Stake (1995, 2000, 2006) to describe an issue under development, or an issue with topical concern that provides (foreshadows) a direction for further research, or helps in reformulating a related issue under study. The literature cited in Section 2.2.1 discussed the concepts of 'preferred suppliers', preferred customers' and 'reverse marketing' in the context of the firm's strategy, with the firm as the level of analysis. However, these concepts are of such topical concern that they can be expected to occur at other levels of analysis as well. For example, the issue of 'preferred suppliers' is likely to emerge when looking at the interactions between the supplier and customer firm at the micro-social level of the analysis, between the individuals in the functions (Design) Engineers, Purchasers, and Sales Engineers.

Likewise, the fact that the MSU survey (Monczka et al., 2000, Figure 2.2) on supplier involvement in NPD did not include the 'white box' type of supplier involvement, can in the context of the present thesis be viewed as a foreshadowed problem in the sense that it provides an opportunity to contribute to the extant theory by investigating how the informal exchanges of information and knowledge take place: what supplier information and knowledge are sought and exchanged, and whether or not they are utilized by the individuals involved in the FFE of NPD.

2.2.2 Models of supplier involvement in the practice of NPD

A central theme in the research on supplier involvement in NPD is the contribution that supplier firms can make in terms of sharing their information and knowledge with the customer firm. The models of supplier involvement in NPD describe the different degrees to which the exchange of information and knowledge takes place.

The next paragraphs briefly outline the models by Bonaccorsi and Lipparini (1994) and Petersen et al. (2003).

Bonaccorsi and Lipparini (1994)

The three models of supplier involvement in NPD that Bonaccorsi and Lipparini developed in 1994 can be found in practice (McIvor and Humphreys, 2004; Wagner and Hoegl, 2006).

The three models, labelled as 'traditional', 'Japanese', and 'advanced', are defined along two dimensions: the timing of supplier involvement, and the degree of competition among suppliers at the time of their involvement.

In the 'traditional' model, the customer firm invites several suppliers to bring out a bid for product parts of a finished product. The product parts are specified in the Bill of Materials (BOM) and defined by (Design) Engineers of the customer firm. The suppliers have no input in NPD.

In the 'Japanese' model, the customer's tier-one suppliers (i.e., prime suppliers who provide parts and materials directly to manufacturers of goods) collaborate in the concept development of products, and participate in the NPD meetings from the very beginning of a NPD project. The customer firm is usually committed to one single supplier, and this limits the firm's access to information from other suppliers.

The 'advanced' model combines the benefits of the Japanese model by involving suppliers in NPD early, but leaves room for getting information from a small group of 'preferred' supplier firms (defined in Section 2.2.1) that are involved in NPD before the product specifications are finalized. Preferred suppliers are expected to submit design proposals, based on their own development work, and prior to being selected by the customer firm for the job. The 'advanced' model is prevalent in high-tech industries.

To sum up: although the advanced model of supplier involvement in NPD incorporates supplier information early on in the NPD process, the involvement is non-committal. The supplier firm is not sure if it gets the order. By comparison, the Japanese model focuses on one supplier only, thus enabling the sharing of knowledge, but limiting its scope. Since the decision whether or not to commit the firm to one or more suppliers needs to be reached by consensus between Purchasing and Engineering (Monczka et al. 2000; Fliess and Becker, 2006), the formal and informal social relationships between the parties involved can be expected to come into play.

Petersen et al. (2003)

The social character of the NPD process has been the underlying assumption behind the model of supplier involvement in NPD developed by Petersen and et al. (2003). The model was tested using the case study data obtained from 44 firms in the US, Europe, and Australia concerning their most successful and least successful NPD projects.

The qualitative part of the study involved interviews with NPD and Purchasing managers at manufacturing sites in Japan and the US. Petersen et al. (2003) note that whereas in Japan, technology uncertainty drove the Japanese firms to establish closer relationships with supplier firms, in the US the opposite happened, technology uncertainty resulted in lower supplier involvement due to a lack of trust.

The research model examines how four factors that emerged from the interviews as the most contributing factors to successful integration of suppliers in NPD, affect the relative success of NPD projects. The four factors are:

- Customer knowledge of supplier;
- Technology and cost information sharing;
- Supplier involvement in decision making; and
- Technology uncertainty.

The findings of the study show that project outcomes were significantly associated with greater supplier involvement in the NPD team. The findings further underline that knowing the supplier firm well is a necessary precondition for greater sharing of technology and cost information between customer and supplier firms. However, having a formal supplier assessment procedure in place is not a sufficient guarantee that a joint NPD project will go well.

Only trusted suppliers with a proven track record should be considered. Open line dialogues and supplier participation in decisions are other important requirements.

The firms in the study exchanged information through technology roadmaps, target pricing (alternative technical solutions to meet a target cost), co-location of personnel, or by creating a 'bookshelf' of potential untested technologies. Greater sharing of technology information helped mitigate technology uncertainty of NPD projects.

The relevance of the research by Petersen et al. (2003) for the present thesis lies in the finding that supplier involvement in NPD did not only occur through formalized channels of NPD projects, but also through informal channels involving NPD-related work meetings among individuals from the customer and supplier firm.

The next paragraphs will therefore take a closer look at the information interrelationships between the functional areas in NPD, starting with a brief introduction into the role of tacit and explicit knowledge in NPD.

Knowledge in NPD: tacit and explicit

Most discussions of the exchange of knowledge open with definitions of tacit knowledge (Polanyi, 1966) and explicit knowledge, and their conversion (Boisot, 1999; Jasimuddin et al., 2005; Nonaka and Takeuchi, 1995; Skyrme, 2001). Although the two types of knowledge are frequently presented as each other's opposites, Polanyi - who coined the term tacit knowledge - has always maintained that tacit and explicit knowledge are not sharply divided:

> *While tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. Hence all knowledge is either tacit or rooted in tacit knowledge. A wholly explicit knowledge is unthinkable (Polanyi, 1966: 7).*

In the context of supplier involvement in NPD, the Purchaser's knowledge that relates to costs efficiency and operational logistics can be described as explicit knowledge because it is codified (i.e., it is predefined information articulated in codes, facts, or rules), and it is easy to transfer. Examples of explicit knowledge are the standard supplier performance metrics, such as product volume, purchase prices, quality certification data, and delivery times, which are available in databases, and can be accessed and transferred electronically.

In contrast, the knowledge of (Design) Engineers relates to solving a specific NPD problem. Such knowledge can be characterized as tacit knowledge because it represents personalized knowledge and know-how. It is knowledge that (Design) Engineers from both the customer and the supplier firm have acquired and interpreted through their work experience. The (Design) Engineers bring this tacit knowledge into the NPD process to share with others in face-to-face interactions.

Hansen et al. (1999) propose that the utilization of tacit knowledge and explicit knowledge lies at the basis of two knowledge strategies of firms. The utilization of explicit knowledge is the goal of a codification strategy, which aims to capture, store, and reuse knowledge in explicit form with the support of IT technology. An example would be configuration files of tried out design solutions that (Design) Engineers can reuse many times over. On the other hand, the utilization of tacit knowledge is the goal of a personalization strategy which draws on interpersonal relationships among the employees in order to make tacit knowledge disseminated across the firm. The setting up of cross-functional teams so as to facilitate the exchange and sharing of information across functions and disciplines of the firm is an example of a personalization strategy. According to Hansen et al. (1999) an effective knowledge management strategy should have a 80/20 balance between the two strategies, that is 80% codification and 20% personalization, or 80% personalization and 20% codification. Subsequent research suggests a more nuanced division (Kumar and Ganesh, 2011; Scheepens et al., 2004). In fact, Jasimuddin et al., (2005) propose a symbiosis of the two strategies, arguing that the currently prevailing view that categorizes knowledge into tacit and explicit should make place for a view that regards both knowledge types as a graded continuum. Skyrme (2001: 24) draws attention to the combinatory value of the two types of knowledge:

> *While codified general knowledge may have relatively low value, the addition of human judgment and experience can considerably enhance value […] Taken together, tacit and explicit knowledge are a powerful combination.*

Translated into the context of the FFE of NPD, the above assertion can be read as a signal of the potential benefits that can result from combining the knowledge of (Design) Engineering and Purchasing. Research by Dowlatshahi (1998) has already shown that inter-functional information relationships are essential to supplier involvement in NPD.

Functional interrelationships in NPD

Dowlatshahi (1998: 145) conceptualizes early supplier development as a collaboration and interrelationship among four parties (building blocks) that determine the nature and scope of supplier involvement, namely: the firm's two internal parties of

Engineering (Design and Manufacturing), the firm's Purchasing, and the external party of Suppliers. Dowlatshahi (1998) proposes that a formal NPD team should include members of each building block, and that each building block should consider the impact of its own tasks in relation to the tasks of the other building blocks. The building blocks should not act in isolation but should keep each other informed. Paraphrasing Dowlatshahi (1998), the functional interrelationships work as follows.

Determining the costs of raw materials at the Design stage is a crucial task that can affect the competitiveness of the firm, but this decision cannot be made in isolation. Purchasing's task to negotiate prices and selecting suppliers should be considered. The negotiated prices should be consulted with the Designer before a decision about material selection is made. The selected Supplier needs to be contacted in order to discover whether the part is a standardized item, or if it can be standardized given the Purchasing's order size.

The ability of a Supplier to provide these items at a reasonable price, and on a timely basis, is affected by the information about the order size from Purchasing. The appropriate levels of product specifications, tolerances and scrap ratios should be developed jointly by Design and Manufacturing since they affect quality targets, production processes, and total product costs. The task of Manufacturing is to determine the size of production runs and that is affected by the availability and the timing of the defect-free Supplies.

Dowlatshahi (1998: 150) points out that when the decisions are made in isolation by the Designer without obtaining appropriate information from Purchasing, Supplier, and Manufacturing, such decisions may lead to a disruption in production, a high cost of purchased materials, and a loss of Supplier goodwill.

Summary Section 2.2.2

The proposal to view explicit and tacit knowledge as a graded continuum rather than two opposite ends of the knowledge spectrum (Jasimuddin et al., 2005; Skyrme, 2001) fits in well with the collaborative environment of the FFE of NPD in which the codification and personalization knowledge strategies (Hansen et al., 1999) can be said to converge. The interrelationship between the codified market knowledge of Purchasing and the often tacit knowledge of (Design) Engineering, and how the interrelationship manifests itself in the interaction with suppliers, has been aptly illustrated by Dowlatshahi (1998).

The research of Dowlatshahi (1992, 1997, 1998, and 2000) on the interfunctional linkages is closely related to the subject of the present thesis. Although Dowlatshahi (1998) does not specifically mention information relationships, but talks instead about functional interrelationships, it is likely that the content of these functional interrelationships pertains to information exchanges. The functional areas involved in the information exchange are similar to the functions studied in the present thesis. But there are differences.

In the research of Dowlatshahi (1998), the functions on the supplier side are not specified. In the present thesis, the Supplier's Sales Engineer is the designated front line contact for Purchasing and (Design) Engineering of the customer firm.

While Dowlatshahi (1998) considers supplier goodwill in the context of manufacturing logistics, the present thesis considers supplier goodwill (benevolence) in the context of supplier information and knowledge in the FFE of NPD. In other words, what type of supplier information and knowledge do (Design) Engineers seek and what type of information do the Supplier's Sales Engineers provide?

2.2.3 The relational benefits of supplier involvement in NPD

Johnsen (2009), in his literature review, divides the research on supplier involvement in NPD into two streams. The earliest research focused on the benefits of supplier involvement that were tangible and related to NPD performance. This research had its origins in the first empirical studies on the practice of supplier involvement in the Japanese automotive industry. Later, studies on other industries (e.g., food industry, packaging) followed (Bonaccorsi and Lipparini, 1994; Lakemond et al., 2006; Van der Valk and Wynstra, 2005).

From about the year 2000 and onwards, the research started focusing on the long term intangible benefits that accrue from partnership relationships and knowledge exchange between buyers and suppliers (Hillebrand and Biemans, 2004; Petersen et al., 2005; Van Echtelt et al., 2008; Wynstra and Ten Pierick, 2000;).[1]

The next paragraphs describe the research focusing on the intangible relational issues in supplier involvement in NPD: relationship management, relationships capabilities, and trust.

The Supplier Involvement Portfolio: relationship management tool

The basic premise behind the Supplier Involvement Portfolio developed by Wynstra and Ten Pierick (2000) is that relationships with suppliers are not static, but respond to changing situations across different stages of NPD projects. The need for supplier input may vary from project to project, and also within the project itself. For example, modifications in product design require less input from suppliers than defining product specifications.

Therefore, the decisions regarding supplier involvement in NPD relate not only to the choice of timing for supplier involvement, but the decisions must also take into account the supplier's specific expertise, and the appropriate form of supplier involvement. The Supplier Involvement Portfolio aims to provide support and guidance to the firms' management in taking such complex NPD decisions, and in coordinating supplier involvement.

[1] But there are exceptions. For example, the 1993 book by Richard Lamming, "Beyond Partnerships: Strategies for Innovation and Lean Supply". The book leads the way with advocating supplier relationship assessment, cost transparency, and supplier development as a two-way exchange of information from which both the customer and the supplier benefit.

The Supplier Involvement Portfolio is based on a trade-off between the degree of responsibility that the customer firm assigns to the supplier for the development of a particular product part, and the overall development risk relating to the importance of that product part to the final product. The resulting Portfolio, a two-by-two matrix consisting of four quadrants, presents four types of supplier involvement, namely:

- Strategic Development (a high degree of supplier responsibility for product development and a high overall development risk);
- Critical Development (a low degree of supplier responsibility for product development and a high overall development risk);
- Arm's Length Development (a high degree of supplier responsibility for product development and a low overall development risk); and
- Routine Development (little or no supplier responsibility for product development and a low overall development risks).

Wynstra and Ten Pierick (2000) emphasize that since each of the four types of supplier involvement has to cope with different levels of uncertainty and ambiguity, each type requires different ways and intensity of communication in order to achieve the desired exchange of information and knowledge between the customer and supplier firm. In consequence, the Supplier Involvement Portfolio recommends a face-to-face interaction in situations when suppliers are involved in the conceptual stage of Strategic Development: the projects are still ill-defined, and the exchange of know-how and experience requires short and fast lines of communication in order to arrive at a common understanding of the NPD problem.

Wynstra and Ten Pierick (2000) suggest that using the Portfolio as a tool can save time on supplier involvement coordination. Furthermore, the Portfolio enables the management to gauge which NPD situations are best suited for increasing supplier engineering responsibility and adjust the future supplier involvement accordingly.

Relational capabilities

Closely related to the research on the relational benefits of supplier involvement in NPD, is the research on the relational capabilities of buyers and suppliers. The exchange of information and knowledge can only begin when the customer firm is prepared to abandon its arm's length relationship with suppliers, and to adopt a relational approach instead (Cox, 1997; Croom, 2001; Dyer and Singh, 1998; Knudsen, 2007; Kogut and Zander, 1992).

Croom (2001) makes a distinction between an operational and relational capability of the firm. The operational capability refers to technical and economic issues, such as a superior manufacturing system, or rapid delivery. The relational capability, on the other hand, relates to institutional and social issues, such as formal and informal social ties between individuals, groups, and firms' functional areas. Such relations are particularly useful in exchanging tacit knowledge.

Croom (2001) argues that whereas operational capability of the firm is unsustainable (i.e., it can be replicated by the competitors), the relational capability can become a unique source of competitive advantage because it is difficult to replicate.

Gulati et al. (2000: 208) make a similar comment with regard to social ties:

> *It is not difficult to see how certain tie characteristics might not only be valuable but also difficult for competitors to imitate.*

Sobrero and Roberts (2002) in their case studies of supplier-customer relationships in the Major Home Appliance industry, also emphasize the role of relational capabilities, when they point out that standard contractual coordinating mechanisms between the customer and supplier firm don't take into account the long term benefits of learning that can accrue from creating ties and connections for repetitive interaction and exchange of information and knowledge; i.e., from having information transferring mechanisms in place. The case study further established that for the relationship outcomes to generate positive results, the investments in the information transferring mechanisms by the two firms, in the form of trust building and commitment, must be congruent with the task at hand.

The congruence of tasks between the customer and supplier firm (Sobrero and Roberts, 2002), cannot, however, be taken for granted. Tuli et al. (2007) in their depth interviews with some 100 managers of customer and supplier firms discovered that the two groups had different perceptions and expectations regarding customer-supplier relationships. The suppliers, in their quest to differentiate themselves from the competitors, have moved from offering products to offering solutions (Windahl and Lakemond, 2006). The interviews of Tuli et al. (2007) showed that in suppliers' view a solution is a bundle of products that are customized and integrated to address a customer's specific business need. In contrast, most interviewed managers from customer firms viewed a customized and integrated bundle only as a part of a solution. They viewed a customer solution as a set of relational processes. In addition to customization and integration, they expected suppliers to help define product requirements, and provide deployment and post deployment support. The managers of customer firms indicated that in order to understand the needs of the customer firm well, the supplier firm should have multiple social ties with diverse stakeholders inside and outside the customer firm.

A case study by Windahl and Lakemond (2006) drew a similar conclusion but emphasized the network horizon of the customer firm; i.e. its position in a broader business network that could include research organizations. The interaction between the supplier offering an integrated solution, and taking into account the impact of the proposed solution on the customer's core processes were critical factors, but so was the connectedness, that is, the relationship ties that both the supplier and customer firms maintained with other actors in the business environment in which they were embedded.

The relational embeddedness (i.e., close ties stemming, for example, from previous joint projects) was found to play a role in the selection of business partners. The finding by Knudsen (2007) that firms primarily partner with firms from their own industry suggests that relational embeddedness is easier achieved among firms with a similar knowledge base. However, several scholars (Bonner and Walker, Jr., 2004; Knudsen, 2007; Lau et al. 2010) found that partnering firms with a similar knowledge base could only provide homogenous knowledge (i.e. knowledge similar to that that the firm already had), and that such knowledge overlap had as consequence that joint NPD projects resulted in incremental innovations only. Scholars, therefore, recommend that firms seek ties and connections with firms that can provide heterogeneous knowledge, even though the relationships with such firms are less embedded in past collaborative activities.

The discussion about the selection of business partners resembles the discussion concerning the benefits of strong and weak ties (Granovetter, 1973, 1982) that posits that a strong tie relationship enables learning and transfer of knowledge because the relationship is based on trust and commitment between the two partners. However, strong tie relationships show redundancies in knowledge, whereas weak tie relationships enable access to diverse and novel information and knowledge. The research on the relational capabilities of the firm is relevant for the present thesis because the management of information relationships through social ties represents an approach to accessing information and knowledge outside the firm's boundaries. The relational capability of the firm can help explain why and when information is sought, and ultimately utilized. (Social ties are the subject of Part Four, Section 2.4.3 in the present literature review).

Trust

The recurring relational theme in the literature on supplier involvement in NPD is the significance of trust for the success of supplier involvement. There is a general agreement that trust cannot be mandated. Rather, trust is viewed as an outcome of gradual and consistent efforts over time (Bstieler, 2006). The significance of time duration is in the literature expressed in terms such as 'trust development' (Ragatz et al., 1997), 'trust formation' (Bstieler, 2006), or 'trust building' (Littler et al., 1995; Johnston et al., 2004; Zhang et al, 2011).

Trust is an essential element in any information and knowledge exchange (Mayer et al., 1995). In NPD, the issue of trust is particularly relevant because of the threat of leakage of proprietary information and technical skills (Ettlie and Pavlou, 2006; Littler et al.,1995; McIvor and Humphreys, 2004; Takeishi, 2002). This concern is compounded by the fact that all information and knowledge applied or created in the course of NPD will eventually belong to the public domain, and can therefore be used or misappropriated in other business areas (Andersen and Drejer, 2009; Littler et al., 1995). An overly dependence on suppliers can in the long run lead to the loss of the customer firm's own expertise (Becker and Zirpoli, 2003; Koufteros et al., 2003).

Spekman and Carraway (2006: 12) sum up the information leakage concerns as follows:

> *The core issue is how much tacit knowledge one can share (or expose) without jeopardizing one's core expertise through the unintended flow of information.*

However, Pawar and Sharifi (2002) present the other side of the information leakage argument, when they posit that supplier's design capabilities are in themselves the accumulation of specialist knowledge resulting from collaborations with a variety of customers. Thus, without such collaboration, the accumulated design knowledge and capability would not exist, and could not be accessed.

The supplier's knowledge accumulation is particularly common in the semiconductor industry (Appleyard, 2003), where multiple chip producers generally have as their supplier the same equipment manufacturer, and where in situations of co-development projects, the equipment supplier serves as a conduit of knowledge between chip producers.

Dowlatshahi (2000) notes that the relationship between the customer and supplier firm must be a win-win situation; otherwise it will not last for long. This contrasts with the finding of a single case study research by McIvor and Humphreys (2004) that reports that the average contract length between the customer and supplier firm is typically no more than 12 months.

Sometimes, however, the importance of common interests between NPD partners overrides the concerns about trust. For example, Lam et al. (2007) studied the sources of conflict in collaborative NPD involving supplier and customer firms, and identified 16 sources of conflict. Surprisingly, mistrust ranked the lowest on the list; i.e., occupied the 16th place. Lam et al. (2007) concluded that once the customer and supplier firm decided to enter into a collaborative relationship, they also trusted each other.

Another example of overriding common interest would be the ad-hoc cooperation in NPD teams in which team members are thrown together for the duration of an assignment. In such situations the team members build their cooperation on 'swift trust' (Meyerson et al., 1996), whereby they substitute relationship-based trust by a quick assessment of member's education, position within the firm, gender, etc.

Summary Section 2.2.3

The cited literature on trust concurs in acknowledging that trust and social relations are conducive to the exchange of information and knowledge in the course of NPD. Supplier involvement in NPD is not static, and neither are trust and social relationships. The relational benefits of supplier involvement in NPD were studied at the level of the firm, but can be expected to occur at other levels of analysis as well.

Therefore, in Figure 2.1, the relational benefits of supplier involvement in NPD (3rd column from the left in Figure 2.1), have been earmarked as 'foreshadowed problems' in anticipation of the Research Questions concerning the 'why's/why not's of the exchange of information and knowledge between the individuals in the functional areas of (Design) Engineering, Purchasing, and Sales Engineering active at the micro-social level of the firm.

2.2.4 Conclusion of Part Two

The motives behind supplier involvement in NPD have undergone a change from focusing on competitive advantage derived from the tangible benefits of supplier involvement (e.g., cost reduction, time to market, and such like) to focusing on competitive advantage derived from intangible benefits of supplier involvement (e.g., trust, long-term relationship, and knowledge exchange between supplier and customer firm). Scholars agree that the practice of supplier involvement in NPD has led to changes in the content and organization of NPD projects.

The exchange of information and knowledge is an inherent part of the NPD process. The Research Questions of the present thesis will therefore seek answers about the content of the information exchanges in the FFE of NPD. What type of information and knowledge is being exchanged between the individuals in the functions of (Design) Engineering, Purchasing in the customer firm and the individuals in the function of Sales Engineering in the supplier firm?

2.3 *Part Three:* The changing roles of (Design) Engineers, Purchasers, and Sales Engineers, resulting from supplier involvement in NPD.

The main themes in Part Three of the literature review (the middle three columns in Figure 2.1) focus on the fields of work allied to the studied functions. The (Design) Engineers are discussed in Section2.3.1, the Purchasers in Section 2.3.2, and the Sales Engineers in Section 2.3.3.

The concern about the firm's functional departments, that live in different 'thought worlds' (Dougherty, 1992) and follow routines that separate rather than coordinate them, is of all times. Supplier involvement in NPD has brought a new urgency to the problem because it imposes extra demands on the organization structure and culture. Handfield et al., 1999: 60) warn that the benefits of supplier involvement cannot be taken for granted:

> *While the benefits of supplier integration appear to be obvious, successful supplier integration initiatives have special common characteristics. Specifically, successful supplier integration initiatives result in a major change to the NPD process. Further, the new process must be formally adopted by multiple functions within the organizations to be successful.*

Several other authors concur with the above view, suggesting that having good working interfaces in place between the functional departments, is a necessary precondition for supplier involvement in NPD (Hillebrand and Biemans 2004; Schiele, 2010; Von Corswant and Tunälv, 2002; Wognum et al., 2002). Further suggestions concern the altering of internal attitudes and procedures which, it is argued, should precede the inclusion of suppliers in NPD projects (Tracey, 2004). Bengtsson et al. (2013) conclude from their findings of an online survey of 681 firms in Europe and North America, that in order to benefit from innovative suppliers, firms need to possess 'knowledge integration capabilities', such as purchasing proficiency and cross-functionality in supplier management. Fliess and Becker (2006) point out that the interfaces between the customer and supplier firm are typically located in two departments of the customer firm: in the (Design) Engineering department for the technical aspects, and in the Purchasing department for the commercial aspects of the collaboration. Fliess and Becker (2006) note that:

> *If the collaboration between the technical and commercial departments does not work, different instructions could be communicated to the supplier intentionally or unintentionally.*

Given the scholarly consensus about the need for ensuring support to supplier involvement in NPD from multiple functions of the firm, and in line with the functional areas chosen to investigate in the present thesis, the next sections will review how supplier involvement has affected the work of (Design) Engineers and Purchasers in the customer firm, and the work of Sales Engineers in the supplier firm.

2.3.1 (Design) Engineers and supplier involvement in NPD

The collaboration of (Design) Engineers with supplier firms is discussed under the headings:

- Historical background of the (Design) Engineer's role in NPD;
- Intra-firm NPD collaborations; and
- The new role of (Design) Engineers in interacting with suppliers (including: Conflicts related to supplier involvement in NPD).

Historical background of the (Design) Engineer's role in NPD

Engineering practice is based on distributed expertise (Trevelyan, 2010). A (Design) Engineer does not work alone but relies on the interactions with other functional areas and disciplines (Carlile and Rebentisch, 2003). Anderson and Drejer (2010) in their case study on engineering work conclude that (Design) Engineers identify themselves foremost as problem solvers, followed by team players, and life-long learners. Over the years, NPD has evolved from a process that was sequential and function-specific, to a process that is concurrent, multi-functional, and integrated.

The change was evolutionary rather than revolutionary, as firms came to realize that they cannot "allow their NPD practices to stagnate because the competitors do not." (Griffin, 1997: 451).

The function of (Design) Engineers reflects this evolutionary change in the growing range and scope of interactions in which the (Design) Engineer participates. The (Design) Engineer has to do more, and know more than he/she did in the sequential design projects when the norm was to work independently of other functions, and when the work's focus was limited to technical design decisions (Hong et al., 2005). At the same time, it has to be remembered that working in teams is familiar ground for the (Design) Engineer. In the words of Bucciarelli (2002: 219-220):

> *Engineering design is the business of a collective or team.[…]. The core of a design collective is of a particular sort. The participants are for the most part members of a firm, - a corporate entity whose purpose is production for profit. In this state they have a common goal, namely to design a product of quality which will contribute to the firm's survival […]. Yet, at the same time, participants in a sense are in competition with one another. Different participants work in different domains on different features of the system; they have different responsibilities and more often than not, the creations, findings and claims and proposals of one individual will conflict with those of another. Negotiations and trade-offs are required to bring participants' efforts into coherence. So while members of a collective share a common goal at some level, at another level their interests will conflict and they will strive in competition.*

The conflicts to which the above quotation alludes could also relate to generational problems. Pilotte and Evangelou (2012) found that the 22 year gap in age and industrial experience between the Baby Boom and Millenium Engineers affected the way the (Design) Engineers communicated and collaborated with each other. Surprising was the finding that despite the availability of social media, when it came to searching for, or exchanging information, both generations prefered face-to-face communications over the use of social media, and the Internet in general. This finding is consistent with earlier research on the ways how (Design) Engineers use and integrate supplier information in NPD (Culley, 1999; Distanont, 20012; Kopecka et al., 2010).

Intra-firm NPD collaborations

In the literature, the first instances of multi-functional cooperation that included (Design) Engineers related to the acceleration techniques in NPD (Zirger and Hartley, 1996), such as concurrent engineering and cross-functional teams. By implementing these techniques, the firms wanted to shorten the NPD process, and thus speed up time to market. Both concurrent engineering and cross-functional teams were conceived as dyadic relationships that paired different functional areas within the firm. Concurrent engineering initially focused on design and process engineering, but later evolved into a concept that promoted the integration of members from several functional areas, including the external partners, such as suppliers (Tracey, 2004).

Similarly, the forerunners of multidisciplinary cross-functional teams were the much researched interfaces between the firm's functional areas, such as the interfaces between:

- R&D and Marketing (Griffin and Hauser, 1996; Gupta and Wilemon, 1985, Moenaert et al.,
- 1990a, 1990a, 1990b, 1994; Moenaert and Souder, 1996);
- R&D and Production (Ginn and Rubenstein, 1986; Nihtilä, 1999);
- Engineering and Purchasing (Anklesaria and Burt, 1987; Dowlatshahi, 1992); and
- Design and Manufacturing (Smulders 2006; Vandervelde and Van Dierdonck, 2003).

The underlying premise of both concurrent engineering and cross functional teams is that the NPD process is an information processing activity (Brown and Eisenhardt, 1995; Griffin and Hauser, 1996; Moenaert et al. 2000), and that the speed of information processing affects a product's time to market.

Further research drew attention to the composition of cross-functional teams. The diversity of functions and disciplines represented in NPD teams (Buijs, 1978; Griffin and Hauser, 1996; McDonough III, 2000; Moenaert and Souder, 1990 a,1990 b, 1996; Moenaert et al., 1994; Hargadon, 2003) was found to be conducive to the success of NPD projects. Following these research findings the firms have started extending their cross-functional teams to also include employees of supplier firms (Ragatz et al., 1997; Cousins et al., 2011). The growing number of interfaces in NPD and the challenges they present for the management of NPD projects is illustrated by the Interface Assessment Tool developed by Lakemond et al. (2013). The tool, which identifies the factors that frequently present challenges for NPD projects, is based on a three year case study of five medium-sized manufacturing firms, each of which participated with one recent and one on-going project.

The new role of (Design) Engineers: interacting with suppliers

For the (Design) Engineer, suppliers represent more than just another interface in the exchange of information and knowledge. The theoretical measurement framework developed and tested by De Toni and Nassimbeni (2001) contains several criteria with which (Design) Engineers can evaluate supplier support. Among the support activities in the fuzzy front end of NPD were the following:

- Suppliers acted as gatekeepers and helped identify new materials, products and manufacturing processes;
- Suppliers provided information regarding the choice of components; suggested standard components if available;
- Suppliers proposed ways to improve the product structure so as to simplify the assembly and manufacturing of the product and make it less costly (Design for manufacture -DFM and Design for assembly-DFA);

- Suppliers made timely and reliable prototypes thus providing (Design) Engineers with information feedback on product specifications; and
- Suppliers informed (Design) Engineers promptly about modifications made during prototyping, thus speeding up the work of redesigning.

The value of supplier support during NPD is evident from the remark by Dowlatshahi (2000) that specific suggestions from suppliers regarding new product designs should be treated as equivalent to R&D investments made by the customer firm. Such approach, of course, presupposes that the suggestions of suppliers are welcome. Research into supplier involvement in NPD, however, has shown that (Design) Engineers were often hesitant to accept suggestions from suppliers (Petersen et al., 2003).

The (Design) Engineers can approach supplier collaboration with an attitude of the 'Not Invented Here' (NIH) syndrome (Katz and Allen, 1982). A case study by Castaldi et al. (2011: 994) uncovered that a typical reaction of R&D Engineers to supplier involvement might run as follows:

> *So that supplier has an idea for us, huh? Let them give us a call sometime and we might take a look at it…*

An alternative approach to supplier involvement in NPD is to accept supplier suggestions as an opportunity of 'Need not be Invented Here' (Hansen, 1999). The case study by Harryson (1997) shows how such an approach worked at Canon and Sony. The two firms deliberately reduced the internal specialized R&D in favor of 'learning through relationships', that is, through combining the internal 'know-how' with the 'know-who' from external sources of technology, such as key suppliers and universities.

The transfer of know-how can also be achieved through co-location of supplier's (Design) Engineers at the customer firm. The so-called 'guest engineers' are salaried employees of the supplier who work for the duration of the NPD project side by side with the customer's engineers (Twigg, 1998; Lakemond et al., 2006; Liker and Choi, 2004; Petersen, 2003; Schiele, 2012). Wagner and Krause (2009) describe the exchange of employees between the customer and supplier firm as 'a very rich mode of communication' that enables the transfer and sharing of tacit complex knowledge.

Conflicts related to supplier involvement in NPD

Inherently, the collaboration in NPD is not free from conflicts. Research by Lam et al. (2007) involving manufacturing experts from four industrial sectors in Hong Kong, identified several sources of conflict in customer-supplier NPD collaboration.

The highest conflict intensity (46.5%) in NPD was found in the Concept Development phase, followed by the Engineering Design phase (30.1 %). The least conflict intense phase was the Production phase (23.4 %).

On the list of frequency of occurrence, conflicts about NPD costs ranked first, conflicts caused by differences in technical belief ranked second, and conflicts about time schedules ranked third.

Lam et al. (2007) note that the fact that the second highest ranking of conflicts relates to differences in technical beliefs indicates the inevitability of conflicts in situations when people from different disciplines and backgrounds work together. Lam et al. (2007) point out that the exchange of information is one of the critical factors in collaborative NPD as is borne out by the fourth and fifth ranking of conflicts related to, respectively, the 'unclear product specifications, or design objectives' and the 'incorrect or incomplete exchange of information'.

Lam et al. (2007) also studied how conflict handling styles related to NPD performance. The conflict handling styles were defined from the supplier perspective, and resulted in five categories, namely: 1/ integrating; 2/ avoiding; 3/ obliging; 4/ dominating; 5/compromising. The 'integrating' conflict handling style was found to be most positively related to NPD performance because it ensured that both parties were committed to the reached solution. The 'obliging' style was also positively related, but only as long as it did not detrimentally affect the immediate benefits of suppliers. The 'avoiding' and 'dominating' styles were negatively related to NPD performance. The use of 'compromising' style had no significant relationship between conflict resolution and NPD performance, but was most frequently used by suppliers. Lam et al. (2007) recommend that suppliers should adopt the 'integrating' conflict handling style more frequently, as it allows for a synthesis of diverse ideas, and it leads to better decision making.

Summary Section 2.3.1

The composition of NPD teams is no longer based on the functions internal to the firm, but teams increasingly include (Design) Engineers from the supplier firm. Co-location of (Design) Engineers from the customer and supplier firm helps the transfer of complex (tacit) knowledge (Lakemond et al., 2006; Petersen, 2003; Schiele, 2012; Wagner and Krause, 2009). The traditional knowledge of (Design) Engineers, the 'know-what' and the 'know-how' has been augmented by the 'know-who'; i.e., the (Design) Engineer knows whom to contact for information in the supplier firm.

The contribution that the supplier's information and knowledge can make to the work of the (Design) Engineer in the FFE of NPD has so far not been included in the research that addressed the use of information in the FFE of NPD (Frishammer, 2005; Monczka et al., 2000; Zahay et al., 2004). Therefore, providing new insights about how supplier information and knowledge are perceived and utilized by (Design) Engineers in the FFE of NPD will contribute to the development of theory on supplier involvement in NPD.

2.3.2 Purchasers and supplier involvement in NPD

The next paragraphs review the Purchasing's role in supplier involvement under the headings:

- Historical background of Purchasers' relationships with suppliers;
- Purchasers' participation in NPD;
- The Purchasing Integration Framework;
- The new role of Purchasers: interacting with suppliers;
- Supplier development; and
- The Practice of supplier development.

Historical background of the Purchaser's relationship with suppliers

Given the central role that Purchasing plays in the contacts between supplier and customer firms, the literature soon came to regard Purchasing as a function that should assume more strategic responsibilities, and take active part in the firm's overall NPD strategy.

Two, now-seminal, Harvard Business Review articles (Kraljic, 1983; Burt and Soukup, 1985) pleaded the case for Purchasing to become a strategic function of the firm, and suggested two different approaches to achieving it.

Kraljic (1983) argued that Purchasing should become an integral part of the firm's supply chain management because of its unique position to identify critical or bottleneck suppliers in the supply chain. On the other hand, Burt and Soukup (1985) made a case for involving Purchasing in NPD, arguing that Engineering and Purchasing should view NPD as a joint venture, and engage in a continuing dialogue similar to that between Engineering and Marketing. The two approaches represent two different ways of handling information and knowledge, as pointed out by Wynstra et al. (2003: 76):

> *The essence of the difference between Purchasing integration [in NPD] and managing supplier involvement is the collection and dissemination of information before or parallel with the actual involvement of suppliers.*

These two different ways of handling information have been incorporated in the Framework for Purchasing Integration, developed by Wynstra et al. (2003). The Framework discerns two kinds of information related activities that Purchasers perform at the Product Management level, namely: 'extending informing' and 'restrictive informing'.

The 'extending informing' activity involves providing information about new products and technology developments in supplier markets, suggesting alternative suppliers, products and technologies that can result in a higher quality of the final product. In contrast, the 'restrictive informing' activity concerns the evaluation of product designs in terms of component availability, manufacturability, lead-time, costs, and promoting component standardization through Preferred Parts Lists.

Castaldi et al. (2011) made a similar point when they described Purchasing as a boundary spanner, linking the firm's competitive strategies outside and inside the firm. On the one hand, Purchasing contributes to the firm's outside competitive strategy through supply chain management when it engages in finding and screening information on innovative suppliers (Ellram and Carr, 1994; Gelderman and Van Weele, 2002; Johnson and Leenders, 2009; Kraljic, 1983; Lamming, 1993; Lakemond et al., 2001, 2006; Schiele, 2006, 2010; Van Weele, 2010; Wagner and Johnson, 2004). On the other hand, Purchasing contributes to the firm's inside competitive strategy for innovation through participating in NPD by providing information on alternative suppliers, component prices and availability (Burt and Soukup, 1985, Di Benedetto et al., 2003; Primo and Admundson, 2002; Wynstra et al. 1999, 2000, 2003).

The general enthusiasm for the central role of Purchasing is somewhat tempered by a retrospective longitudinal case study (Dubois and Wynstra, 2005) which studied the Purchasing's behavior of a manufacturer of electric fork-lift trucks in relation to changes in the supplier base over four decades. Dubois and Wynstra (2005: 76) note that:

> *Based on this case study we may suggest that although the Purchasing department is always an active party in implementing changes in the supplier base, its role in initiating and influencing change can display huge variations. Hence, mainstream textbooks may seem to overemphasize the role of Purchasing and the Purchasing department as a "change agent'. This does not suggest that the Purchasing function is of little importance to the performance of the company, but that its ability to pursue its own strategy is limited. An alternative view on the Purchasing function, which may better describe its role, is to regard it as an interface between the operations of the buying company and the suppliers.*

The role of Purchasing in the supplier interface management has been identified as a crucial factor in the Purchasing Integration Framework (Wynstra et al., 1999, 2000, and 2003), which is described below.

Purchasers' participation in NPD

Wynstra et al. (2001) have specified three critical prerequisites for managing supplier involvement in NPD. First, to identify specific processes and tasks that would allow broader participation of Purchasing in NPD. Second, to form an organization that supports the execution of such tasks. Third, to staff the organization with people who have the right skills.

Research by Lakemond et al. (2001) has shown that firms have a number of choices available with regard to involving the function of Purchasing in NPD projects.

Lakemond et al. (2001) developed and tested a typology of six configurations of Purchasing involvement in NPD. The configurations ranged from ad-hoc contacts between Engineering and Purchasing, to configurations in which a Purchasing Coordinator was added to project teams, or configurations in which a Purchasing Specialist was integrated in the project team on a part-time, or a full-time basis, in addition to the already added Purchasing Coordinator.

Case studies in Dutch and Swedish firms, with the NPD project as the unit of analysis, validated three of the six configurations, namely:

- the configuration of ad-hoc contacts between Engineering and Purchasing;
- the configuration of a part-time integration of a Purchasing Specialist in combination with a Purchasing Coordinator; and
- the configuration of full-time integration of a Purchasing Specialist in combination with a Purchasing Coordinator.

The case study findings indicated that the NPD projects with higher project complexity and size showed a higher need for a more permanent integration and coordination of Purchasing activities.

Purchasing Integration Framework

The integration of Purchasing in NPD has been the subject of extensive research by Finn Wynstra and colleagues who carried out two series of exploratory case studies on the manufacturer-supplier relations in 18 Dutch and Swedish firms from different industries (Wynstra et al., 1999, 2000, and 2003).

The research resulted in the development of an activity-based Framework for Purchasing Integration in NPD.

The framework identifies five key processes that lie at the core of structuring and managing supplier involvement in NPD, and through which the integration of Purchasing in NPD can be examined. The five key processes are: prioritizing, mobilizing, coordinating, timing and informing. These five key processes span across four different areas of NPD management, namely: Development Management, Supplier Interface Management, Project Management, and Product Management.

- In the area of Development Management, Purchasing is involved in prioritizing which technologies to keep/develop in house and which technologies to outsource, and in coordinating/informing about policies and procedures with regard to supplier involvement;
- In the area of Supplier Interface Management, Purchasing gathers information about the suppliers' technical capabilities, and prioritizes, coordinates and mobilizes supplier participation in NPD;
- In the area of Project Management, Purchasing participates in prioritizing the develop-or-buy solutions, in selecting suppliers, and in coordinating, timing and informing development activities between tier-one and tier-two suppliers and the Purchasing's firm; and
- Finally, in the area of Product Management, Purchasing provides information about new products and technologies available through supplier markets. Purchasing also prioritizes alternative suppliers, informs about product parts availability, lead time, quality, costs, and manufacturability, in addition to mobilizing awareness of standardization of product parts.

Wynstra et al. (2003) emphasize that although all four areas of NPD management are interrelated, the area of Supplier Interface Management plays a central role from which the other areas derive their own activities. The framework has been applied and validated in a multiple case study of supplier collaborations at a manufacturer in the copier and printer industry in the Netherlands (Van Echtelt et al., 2008).

In the context of the present thesis, the area of Supplier Interface Management involves interactions between Purchasers and (Design) Engineers on the one hand, and interactions between Purchasers and supplier's Sales Engineer on the other. Dowlatshahi (2000) suggests that, ideally, Purchasers and (Design) Engineers should form a team that represents the customer firm vis-à-vis the supplier firm, and that this team should visit supplier sites so as to encourage additional discussion and information sharing. The present thesis will address the possible formation of such teams when it investigates the dyadic information relationships between (Design) Engineers, Purchasers, and Sales Engineers.

The potential of Purchasing to effectively interface with suppliers largely depends on personal characteristics of the Purchaser, his/her professional knowledge (e.g., tenure), and his/her autonomy of action; i.e. having discretionary powers to reach a compromise (Perrone et al. 2003; Zhang et al., 2011). Research by Perrone et al. (2003) showed that Purchasing Manager with greater autonomy of action engendered more trust from supplier representatives. Zhang et al. (2001) viewed Purchasers as the visiting card of their firm, who projected the trustworthiness of their firm. Zhang et al. (2011) found that while supplier's trust in a Purchaser resulted in supplier's trust in the Purchaser's firm, the opposite did not hold true. When a supplier firm trusted a customer firm, it didn't automatically follow that the supplier firm was going to trust the customer's Purchaser as well. Zhang et al. (2011: 326) concluded that: "interpersonal relations could be sources of inter-organizational relational rents". However, since Purchasers are not a homogenous group, the relational rents achieved through Purchaser's professional knowledge and capabilities cannot be taken for granted.

Cousins et al. (2008) developed and empirically tested a taxonomy of Purchasing functions based on data from 151 UK firms. The resulting four configurations, termed 'strategic', 'celebrity', 'capable' and 'undeveloped' describe the Purchasing function in terms of the levels of strategic planning, status, internal integration, and skills. The configurations can be said to reflect the evolution of the purchasing function from administrative to strategic. But the configurations can also be taken as evidence of the importance of the Purchaser's personal characteristics. For example, the configuration 'celebrity Purchasers' was found to have high levels of status in the eyes of top managers, yet had statistically lower knowledge and skill levels than any other configuration. Cousins et al. (2008) suggest that the high status may be the result of price savings achieved through the Purchaser's hard negotiations with suppliers.

By comparison, the configuration 'undeveloped Purchasers', had knowledge levels that were not statistically different from those of 'strategic' or 'capable' Purchasers, but their participation in strategic planning was low.

Although unstated by Cousins et al. (2008), it could be argued that the lesser prominence of 'undeveloped Purchasers' was probably due to the absence of an enigmatic personality of the 'celebrity Purchaser' in the ranks of 'undeveloped Purchasers'. The issue of Purchaser's personal characteristics is relevant for the present thesis because it studies the exchange of information and knowledge in the FFE of NPD from the perspective of social relationships between individuals in the FFE of NPD, including the Purchasers.

The new role of Purchasers: interacting with suppliers

"Just as Marketing is scanning the environment for unfulfilled needs, and R&D is developing/acquiring new technology, so is Purchasing actively acquiring, assimilating, digesting, and sharing information on new and forthcoming supplier developments." (O'Neil, 1993 cited by Wynstra et al., 2003: 76). In the context of supplier involvement in NPD, the information gathering about supplier products and their technologies is no longer conducted in the environment of arm's length relationships with suppliers, but in an environment in which the customer firm and supplier firm work together to further develop the supplier firm's capabilities.

Supplier development

A supplier development relationship, according to Lamming (1993, 1996, 2005), should be a jointly owned transparent entity, a relationship without 'paternalistic overtones' (Lamming, 1996:192), meaning that it is not only the supplier firm that needs to develop (or be developed). Such a relational view of joint value creation through collaboration (Dyer and Singh, 1998) clearly moves the emphasis away from the observable, quantifiable supplier outputs to the inputs of supplier relationships (Ulaga and Eggert, 2006; Wagner and Krause, 2009). Croom (2001: 30) cites Lamming (1993) when he states that:

> *[the challenge] is for the collaborators to view [their] relationship [as a distinct] 'third party' [and that] the cost of resourcing [that relationship] must be justified by the value it adds, the cost and time savings, and the mutual competitive advantage that it provides.*

Krause et al. (2007: 529) gave a following definition of supplier development:

> *Supplier development is any effort by an industrial buying firm to improve the performance or capabilities of its suppliers.*

Scholars are in agreement that supplier development and supplier audits provide opportunities to exchange information and knowledge between participating firms (Giannakis, 2008; Krause and Ellram, 1997; Krause et al.(2007); Modi and Mabert, 2007).

The foregoing definition of supplier development by Krause et al. (2007) names the performance and capabilities of suppliers in the same breath, as if they were inseparable. However, when viewed from the perspective of knowledge transfer, the two outcomes of supplier development; i.e., supplier performance and supplier capability, represent two distinct processes of information and knowledge exchange (Modi and Mabert, 2007). The differences are not unlike the differences between tacit and explicit knowledge.

Modi and Mabert (2007) point out that developing a supplier firm's performance is a short-term objective which involves an inspection of the firm's operational functions. As a result, the exchange of information is similar to that which takes place between the customer and supplier firm during supplier audits. The information exchange pertains to costs, quality, delivery, and inventory of products. Such operational information is codified and therefore easy to transfer. By comparison, developing a supplier firm's capability is a long-term objective and focuses on technical adjustments in design and production processes. Such technology-related information is often experience-based, and therefore tacit and difficult to transfer.

Wagner and Krause (2009) make a similar distinction between supplier performance and supplier capabilities, but instead of focusing on the exchange of knowledge, they study the degree of human interaction necessary to bring the exchange of knowledge about. Wagner and Krause (2009) analyze supplier development as three sets of activities. The first set of activities pertains to the compilation of information about the supplier, the evaluation of supplier performance, and the unidirectional provision of supplier's evaluation results to the supplier. The second set of activities involves the provision of specialized and in-depth technical, process, or managerial knowledge. The third set of activities relate to interactive sharing of tacit knowledge through the exchange of employees (co-location). The research findings of Wagner and Krause (2009) suggest that the first set of activities can best be described as supplier management, the goal of which is to improve the supplier's product and delivery performance. By comparison, the latter two activities aim to improve supplier capabilities, and therefore involve interactions and exchanges of information that require a two-way communication process between the employees of the customer and the supplier firm. Wagner (2011) links the effectiveness of supplier development to the life cycle of the customer/supplier relationship, pointing out that the three building blocks of supplier development – trust, commitment, and information exchange – take time to develop and mature.

The practice of supplier development

The research findings of Modi and Mabert (2007) and Wagner and Krause (2009) are consistent with the research findings about the practice of supplier development. For example, the research of Sako (2004) found that Toyota adopted a two-pronged approach to supplier development.

The internal organization of supplier development is decoupled, meaning that the Total Quality Control activities (i.e., the improvement of supplier's operational performance) are carried out by the Purchasing department, whereas the improvements in the production processes (i.e., the improvement of supplier's capabilities) are carried out by a special Engineering consulting division. Since the two departments operate independently of each other, supplier firms are more willing to participate in supplier development schemes because there is no direct link between process improvements and price negotiations.

Similarly, a consortium benchmarking study of six best-practice firms from Germany, Austria, and Switzerland (Schiele, 2010, 2012) also reported a division in the organizational structure of Purchasing. Five of the six best-practice firms divide their Purchasing function into 'advanced sourcing' and 'life-cycle sourcing' units. The 'advanced sourcing' unit interfaces with R&D and is integrated in NPD teams, whereas the 'life-cycle' unit is responsible for purchasing a wide range of commodities across all functions of the firm, and seeks volume benefits by pooling purchasing requirements.

Summary Section 2.3.2

The participation of Purchasers in NPD is on the one hand determined by the type of information and knowledge that they can contribute to the NPD process (Wynstra et al., 2003), and on the other hand by the size and complexity of NPD projects (Lakemond et al., 2001). The capability of Purchasers is in turn determined by the professional knowledge and ability of the individuals representing the Purchasing department of the firm (Cousins et al., 2008; Perrone et al., 2003; Zhang et al., 2011). Developing supplier capabilities through supplier audits belongs to the traditional work domains of Purchasing.

By comparison, developing supplier capabilities represents a new area of work, which requires exchanges of information and knowledge pertaining to design and production processes (Modi and Mabert, 2007; Wagner and Krause, 2009). The research findings from the practice of supplier development (Sako, 2004; Schiele, 2010, 2012) have shown that the development of supplier capabilities is entrusted to R&D and (Design) Engineers rather than to Purchasers.

The research on the role of Purchasers in NPD is closely related to the focus of the present thesis because Purchasers represent one of the three functional groups whose information relationships in the FFE of NPD the present thesis aims to investigate.

2.3.3 Supplier's Sales Engineers and supplier involvement in NPD

The next paragraphs briefly outline the role of the supplier's Sales Engineer in supplier involvement under the headings:

- Historical background of salespeople in NPD;
- B2C setting;
- B2B setting;
- Sales Engineers' role in customer/supplier relationships;
- The new role of Sales Engineer: the Knowledge worker; and
- The transfer of 'sticky' knowledge.

Historical background of salespeople in NPD

The role of salespeople in NPD is different in a business-to-consumer (B2C) setting than it is in a business-to-business (B2B) setting. This difference is given by the dichotomy between consumer and industrial markets (Fern and Brown, 1984). Demand for industrial goods is derived, while demand for consumer goods is primary. Other, but by no means all, differences between industrial and consumer markets pertain to negotiated pricing, the number of individuals involved in the purchase decisions, the frequency of (re)purchase, the number of buyers, purchase rationality, product knowledgeability, and reciprocal buyer/seller relationships. The overall trend among salespeople is a shift from 'persuasive' selling to consultative selling (Rochford and Wotruba, 1993). This trend can be said to foreshadow the emergence of Sales Engineer as a Knowledge Worker (Darr, 2002, 2003, 2006).

B2C setting

In a B2C setting, salespeople take active part in the commercialization phase of NPD, and contribute to product launch success (Di Benedetto, 1999). In fact, salespeople are viewed as a first line customer for a new product (Athuahene-Gima, 1997). The new product adoption by salespeople (reflected in their commitment to the product and their selling effort) has been found to be positively related to selling performance (Hultink and Atuahene-Gima, 2000). The commitment to the product can be increased by 'internal marketing' which aims to sell the benefits of the new product to salespeople by presenting the research behind the product (Hultink and Atuahene-Gima, 2000). This internal exchange of information, however, can run into the barrier of R&D jargon and the differences in time horizons between R&D staff and salespeople (Antioco et al., 2008). The time horizon of R&D staff is long term, whereas salespeople often need the product information at the moment of sale. Although it has been recognized that salespeople could be a potentially unique and valuable source of information about the unmet needs and problems of customers, the participation of salespeople in the early stages of NPD, and in product design decisions in general, has been minimal (Antioco et al., 2008; Judson et al., 2006; Rochport and Wotruba, 1993).

B2B setting

In a B2B setting, industrial products are sold in categories, such as components, materials, and technologies.

The 'customers' of salespeople are (Design) Engineers and R&D staff of the customer firm who derive their need for products from a particular approach to solving a problem (Von Hippel, 1978). Gaining customer trust is an essential element in the work of industrial salespeople (Swan et al., 1985). Equally important is that salespeople are considered as trustworthy by the NPD team within their own firm. According to Joshi (2010), the NPD team looks to salespeople for assistance in three key areas:

- securing customer feedback on new product ideas and development;
- arranging access to key customers to adopt the innovations developed by the NPD team; and
- persuading customers to adopt the innovations of the NPD team.

The compliance of NPD team with the proposals for product modifications that salespeople had submitted, were found to have a positive impact on the product's market performance (Joshi, 2010).

Sales Engineers' role in the customer-supplier relationship

The Sales Engineer's role in customer-supplier relationships can take different forms. As the job title indicates, the Sales Engineer represents the supplier's interests on two fronts: Sales and Engineering. Which part of the job gets an upper hand depends on the kind of relationship that the Sales Engineer's firm has with the customer firm.

In the 'traditional' arm's length model of customer-supplier relationships, which involve supplying component parts for a finished product, the Sales Engineer's main objective is to achieve high sales quota. The first point of contact for the Sales Engineer is the customer's Purchasing department. The exchange of information primarily involves codified information concerning logistics and operational issues. To exchange this codified information, both parties increasingly rely on password protected IT systems (Deeter-Schmelz and Kennedy, 2002). In contrast, in the 'advanced' model of supplier involvement in NPD (Bonaccorsi and Lipparini, 1994) the supplier firm in its capacity of 'preferred' supplier provides customer support in the form of actively helping to solve product design and manufacturing problems. In such situations, the Sales Engineer acts more like an Engineer than like a Salesman. He/she functions as an intermediary between the Design and Manufacturing Engineers of the supplier firm and the (Design) Engineers of the customer firm.

The new role of Sales Engineers - the Knowledge Worker: interacting with (Design) Engineers of the customer firm

In the exchange of information between customer and supplier firms, the Sales Engineer of a preferred supplier fulfills a dual role. In addition to exchanging (codified) knowledge with Purchasing, he/she also facilitates and participates in the exchange of (tacit) information during face-to-face contacts with (Design) Engineers of the customer firm. Thus, the Sales Engineers can be personally involved in co-designing or customizing customer's products.

Since the Sales Engineer is familiar with the engineering practices of both the supplier and the customer firm, he or she is in a position to access the knowledge of R&D labs of his/her firm, and relate this knowledge to customer's needs. In other words, the Sales Engineer can make 'sticky knowledge' unstuck. Sticky knowledge has been defined as knowledge that is costly to acquire, transfer, and use in new locations (Von Hippel, 1994; Szulanski, 2002). In such situations, the Sales Engineer adopts the work style of a Knowledge Worker.

The origins of the concept of a Sales Engineer as a Knowledge Worker dates back to the ethnographic research of Asaf Darr (2002, 2003, 2006). Darr (2002) positions the transition from a Sales Engineer to a knowledge worker in the context of the shift from mass production to mass customization. The result of this shift is a 'technicization of the sales force' (Darr, 2002), and the subsequent blurring of boundaries among design, manufacturing, and sales. This transition has also brought about the growing interdependence between social and technical skills in the work of Sales Engineers (Darr, 2006: 5-7).

In mass markets, both customers and suppliers knew the intended application of a product. The codified information of the product catalogue was sufficient for the customer to learn about the product's price and quality. Thus, the distribution of product information was more or less symmetric. The job of the Sales Engineer was to take care of delivering the right products in the right time and quantity. No technical knowledge and skills were necessary.

With the arrival of mass customization, the application of products has become subject to the evolving needs and wishes of customers. In other words, the customer determines and influences the design and manufacturing process. As a result, the customer and the supplier/manufacturer often need to develop the application of products in a partnership. The distribution of product information is asymmetric because the customer may know more about the potential product application than the supplier: the customer and supplier may no longer have a common image of the product.

Transfer of 'sticky' knowledge

The supplier's Sales Engineer, in his or her function as a knowledge worker, helps reverse the information asymmetry by facilitating the transfer of supplier knowledge and its utilization by (Design) Engineers of the customer firm. To this end, the Sales Engineer needs 'to extract contextual knowledge from the customer's (Design) Engineers through face-to-face interactions' (Darr and Talmud, 2003: 448). In order to be able to transfer the contextual knowledge (i.e., the intended use and function of the product as envisioned by the customer firm) to his/her firm's Manufacturing Engineers, the Sales Engineer must have an in-depth understanding of customer needs, as well as of his/her firm's manufacturing capabilities. Research has shown that contextual knowledge is often 'sticky'; i.e., difficult to transfer (Von Hippel, 1994), but that 'sticky knowledge' can be transferred through social ties (Hansen, 1999; Szulanski, 2002), shared practice (Brown and Duguid, 2001), or through collaborative partnerships (Emden et al., 2006; Von Hippel, 2006). According to Szulanski (2002), one can partially predict stickiness by analyzing the quality of social ties between the information provider and the information recipient because social ties act as conduits for knowledge transfer (Granovetter, 1973, 1982; Levin and Cross, 2004; Levin et al., 2006). The concept of social ties will be further addressed in Part Four, Section 2.4.3 of the present literature review.

Summary Section 2.3.3

The concept of 'technicization of the sales force' (Darr, 2002) breaks with the traditional view about what the work of a Sales Engineer entails. At the same time, the concept opens up the possibility of the supplier's Sales Engineers' participation in the customer's FFE of NPD.

The research on the role of the Sales Engineer in supplier involvement in NPD, and the role of a Knowledge Worker in particular, is closely related to the present thesis because suppliers' Sales Engineers represent one of the three functional groups whose information relationships in the FFE of NPD the present thesis aims to investigate.

2.3.4 Conclusion of Part Three

Part Three of the literature review (the middle three columns in Figure 2.1) discussed the new elements in the work of the functions of (Design) Engineers, Purchasers, and Sales Engineers that were brought about by supplier involvement in NPD. The new roles provide new opportunities to obtain insights into how the exchanges of supplier information and knowledge have developed and deepened. To this end, the Research Questions will seek answers about how the exchanges of supplier information and knowledge in the FFE of NPD between the individuals in the three functions are being effectuated.

Methodological choice: the level of analysis

The literature review informed the choice of the level of analysis. Two of the three functional areas studied in the present thesis are internal to the firm, namely: the functions of (Design) Engineering and Purchasing. The third function, the supplier's Sales Engineering, is external to the firm. The literature review established that all three functions are involved in the FFE of NPD.

In studying the patterns of information and knowledge exchange in the FFE of NPD, the present thesis will adopt as the level of analysis the micro-social level of the firm (Knorr-Cetina, 1981). The choice is motivated by the realization that in order to learn about the patterns of information exchange, we need to understand the interpersonal interaction of the individuals who represent the three functions.

With this methodological choice, the present thesis aims to fill the gap in the research on knowledge sharing that has predominantly focused on processes, and phenomena at an organizational level of analysis, and paid comparatively little attention to micro-level constructs, such as groups and individuals (Foss et al., 2010).

The research on supplier involvement in NPD has shown a similar preference for higher levels of analysis. Scholars (Wynstra et al., 2003; Schiele, 2012) have commented on the fact that most studies had adopted as the level of analysis the firm, the NPD project, and to a lesser degree, the functional units of the firm. With regard to the functional units, it is important to note that the previous research mostly focused on the interaction of the functional units in the context of the firm to which the units belonged (e.g. the units of R&D, Marketing, Purchasing, or Manufacturing), whereas the present thesis studies the interaction of the three functional units across the firm's boundaries.

The research on supplier involvement in NPD (Cousins et al. 2011; Lawson et al., 2009; Petersen et al., 2003) has shown that supplier involvement in NPD does not only take place through formal organizational structures, but also through informal channels involving individuals from both the customer and supplier firms. By choosing the micro-social level of the firm as the level of analysis, the present thesis hopes to shed light on the content and form of these exchanges.

As Frishammer and Ylinenpåå (2007: 442) have pointed out, more insight about what happens within the NPD process is needed, if we are to manage it better. This is even more the case in relation to the FFE of NPD where the information processing is still largely unstructured (Barczak et al., 2009).

2.4 *Part Four:* The social relations' role in the exchange of information and knowledge

The main themes of Part Four of the literature review (the last two columns in Figure 2.1) are:

- Embeddedness;
- Social relations at the network level;
- Structural holes and network closure as sources of social capital;
- The IMP Network Approach;
- Social relations at the interpersonal level;
- Tie strength;
- The combinatory benefits of strong and weak ties; and
- The relational view of social ties; and Social ties in NPD.

The importance of social networks in the exchange and dissemination of knowledge is well established (Allen, et al., 2007; Anderson, 2008; Cross et al., 2001; Borgatti and Cross, 2003; Krackhardt and Hanson, 1993).

A social network consists of a set of actors, or 'nodes', connected with each other by a set of ties. The actors can be individuals, business units, or firms. Each actor's tie represents an information channel through which the actor can access information and knowledge of the other actors (Anderson, 2008). A tie between two actors represents a dyadic relationship.

Informal networks in firms develop because people continually ask one another "who knows what, who has previously provided knowledge that turned out to be useful?" (Davenport and Prusak, 1998: 37). Research on the information seeking behaviour of (Design) Engineers has shown that the (Design) Engineer has preference for accessing information through interpersonal contacts with colleagues (Allen, 1997; Fidel and Green, 2004; Hertzum and Pejetersen, 2000; Hirsch and Dinkelacher, 2004). Similarly, Burt (2004: 388) argues that good ideas do not have to be the result of a creative genius, but can be the outcome of an information exchange, which he refers to as an 'import-export business' of ideas.

> *An idea mundane in one group can be a valuable insight in another. In our age of ready technology, people often make the mistake of thinking that they create value when they have an idea born out of sophisticated analysis. That is not true. An idea is as valuable as an audience is willing to credit it with being.*

Supplier involvement in the FFE of NPD can be viewed as the time for such import-export of ideas. When customer and supplier firms exchange (codified) information and (tacit) knowledge, they engage in an economic behaviour that goes beyond the arm's length market exchanges. Such economic behaviour intentionally draws on the on-going social networks in which the customer and supplier firms are embedded (Granovetter, 1985).

2.4.1 Embeddedness

Mark Granovetter (1985) introduced the concept of Embeddedness in his article published in the American Journal of Sociology (1985), entitled "Economic action and social structure: the problem of embeddedness." According to Swedberg (1997), the article's publication marks the beginning of a new stream of scholarship, the New Economic Sociology. Swedberg (1997) further comments on the flexible quality of the concept of embeddedness, and its capacity to coexist with a number of other approaches in sociology. In addition to the embeddedness of economic action in social networks, the scholars of the New Economic Sociology study the embeddedness of economic action in culture, politics, and religion.
Granovetter (1992: 33) defines embeddedness as follows::

> *Embeddedness refers to the fact that economic actions and outcomes, like all social action and outcomes, are affected by the actors' dyadic (pairwise) relations and by the structure of the overall network of relations.*

Granovetter (1992) makes a distinction between 'relational embeddedness' (the dyadic personal relations of actors) and 'structural embeddedness' (the overall network structure shown in the configuration of ties). Uzzi (1996) suggests that by placing the economic behaviour of firms in the societal context, the concept of embeddedness offers a link between sociological and economic accounts of business behaviour. - Brian Uzzi was, next to Mark Granovetter, a major contributor to the development of the concept of embeddedness. His empirical study of how embeddedness affected the economic behaviour of 23 firms in the New York City apparel industry (Uzzi, 1996, 1997) had as the unit of analysis the interfirm relationship, and the type of embeddedness was 'structural embeddedness'.

The origins of the concept of embeddedness can be traced back to Granovettter's critique of two schools of economic thought (Granovetter, 1985). The first school represents the views held by classical and neo-classical economists. In this view, economic institutions, such as firms, are viewed as atomized actors who make decisions in isolation from one another, abstracted out of their social context, and abstracted from the history of their own relations. The second school represents the views held by New Institutional Economics, and notably by Oliver Williamson in his book 'Markets and Hierarchies' (1975). Williamson posits that economic institutions engage not only in the pursuit of self-interest but also in 'opportunism' which he describes as 'self-interest with guile' (Williamson, 1975: 26). In the view of Williamson (1975), opportunism in business relations refers to lack of honesty and includes behaviours such as lying, cheating, or breaking agreements.

The embeddedness approach challenges both views. It counters the view of atomized actors by presenting economic institutions as being socially constructed, whereby economic action is constrained and shaped by on-going networks of personal relations in which the economic actors are embedded. The embeddedness approach also counters the assumed 'opportunism' in business relations by presenting interpersonal connections as a safeguard against misconduct. In the words of Granovetter (1985: 490):

> *The embeddedness argument stresses the role of concrete personal relations and structures (networks) of such relations in generating trust and discouraging malfeasance. […]. Better than the statement that someone is known to be reliable is information from a trusted informant that he has dealt with that individual and found him so. Even better is information from one's own past dealings with the person. This is better information for four reasons: 1/ it is cheap; 2/ one trusts one's own information best - it is richer, more detailed and known to be accurate; 3/ individuals with whom one has a continuing relation have an economic motivation to be trustworthy, so as not to discourage future transactions; 4/ departing from pure economic motives, continuing economic relations often become overlaid with social content that carries strong expectations of trust and abstention from opportunism.*

The foregoing quotation can be read as an illustration of the direct and indirect effects of trust (McEvily et al., 2003). On the one hand, trust is a safeguard against business malpractices and this has a direct effect on the way the parties engaged in exchanging information approach each other. On the other hand, trust is a facilitator for the exchange of information and knowledge, and as such, it has an indirect effect on the conditions under which collaboration between the exchanging parties takes place.

2.4.2 Social relations at the network level

Although the subject of social relations at the network level is not the focus of the present thesis, a review of the research on social relations at the network level is useful because it holds up a magnifying mirror to social relations at the interpersonal level. The two research streams discussed in the next paragraphs have been selected because of their emphasis on the role of information and knowledge in social relations. The two research streams are:

- Structural holes and network closure as sources of social capital; and
- The IMP network approach.

Structural holes and network closure as sources of social capital

The concept of the Strength of Weak Ties developed by Mark Granovetter (1973, 1983) will be discussed in detail in Section 2.4.3 (social relations at the interpersonal level) of the present literature review. Here, the quotation by Granovetter (2005: 34-35) illustrates the macro-level implications of the concept:

> *If each person's close friends know one another, they form a closely knit clique. Individuals are connected to other cliques through their weak rather than strong ties. Thus, from an 'aerial view of social networks, if cliques are connected than it is mainly by weak ties.*

Structural holes

Weak ties and structural holes are similar in that they both help access non-redundant information. Weak ties achieve this through the strength of relationship between two parties and the tie location within a network. Burt (1992) extends and reformulates the Strength of Weak Ties argument in his concept of 'structural holes as social capital'.

Burt (1992) proposes that it is not the strength of any particular tie that brings the positive outcome (i.e., information access), but the activity of bridging the disconnected parts of the network, and controlling the information flow. "Tie weakness is a correlate not a cause." (Burt, 1992: 27). The activity of bridging lies in the spanning of 'structural holes' that emerge as a result of the lack of ties between two parts of a network (Borgatti and Foster, 2003; Granovetter, 2005). The advantage that accrues to individuals from their position between two disconnected groups in the social network is referred to as 'social capital'. Lin (2001: 19) defines social capital as "an investment in social relations with expected returns in the marketplace."

Burt (1992:10) gives an example of how social capital complements human capital (e.g., education, knowledge, capabilities, skills, etc.) by citing a remark of a colleague: "Publishing high-quality work is important to getting university resources, but friends are essential."

Unlike human capital, social capital is not the property of individuals, but it is owned jointly by the parties engaged in exchange relations (Burt, 1992; Coleman, 1988; Lin 2001).

Networks that are rich in structural holes are referred to as sparse networks (Burt, 2001). An example of a sparse network would be entrepreneurial networks in which structural holes represent entrepreneurial opportunities that skilled entrepreneurs identify and exploit by brokering the connections between others (Burt, 2001). The source of social capital in sparse networks is the underlying mechanism of 'brokerage' that enables the broker (i.e., the actor who is closest to structural holes) to adopt the strategy of 'Tertius Gaudens', the 'third who benefits'. The broker's social capital arises from the benefits of bridging a gap between two unconnected parties, and from being able to control the flow of information to the broker's advantage. However, the benefits of structural holes may diminish over time: information declines in value, windows of opportunity may close. This phenomenon is known as bridge decay (Burt, 2002; Soda et al., 2004). Therefore, to stay effective as well as efficient Tertius Gaudens needs to invest time and effort only in the maintenance of a selection of bridge ties. Otherwise, bridge ties will fall into their natural state of being weak ties (Burt, 1992: 30).

Network closure

Dense networks (Coleman, 1988) represent another way of creating social capital. The source of social capital in dense networks is the underlying mechanism of 'network closure'. Dense networks represent closely knit groups where everyone is connected to everyone. The concept of 'closure' refers to the network cohesion and conformity. Dense networks provide stability and efficiency as network members conform to common norms of behaviour, develop common routines for the exchange of information and knowledge, and create shared meanings, understandings and trust. The network closure provides the basis for sanctioning opportunist behaviour.

Unlike the value of social capital created by sparse networks (structural holes), the value of social capital created in dense networks (network closure) persists over time, although it takes longer before it becomes beneficial because developing the common norms of behaviour requires time (Soda et al., 2004).

The IMP network approach

The IMP (International Marketing and Purchasing) Group www.impgroup.org is a predominantly European group of scholars concerned with developing concepts and knowledge in the field of business-to-business marketing in general, and customer/supplier relationships in particular.

Similar to the concept of Embeddedness, the IMP Group holds the view that economic behaviour of firms is not an autonomous activity. The statement "No business is an island" (Håkansson and Snehota, 1989, 2006) epitomizes the central role that the IMP research assigns to the interaction and relationships between, among, and within firms.

Likewise, Baraldi et al.(2007) question the "Myth of Independence" (Ford, 2003): that a firm is able to act independently, can carry out its own analysis of the environment in which it operates, can develop and implement its own strategy based on its own resources, taking into account its own competences and shortcomings. Viewed from the relationship and network perspective, the opposite may be the case. Firms have a restricted view of the surrounding network, have limited freedom to act independently, and the outcome of their actions depends on the actions of other firms within the network (Baraldi et al., 2007).

Håkansson (1987: 88-89) underlines the instability and imperfection of networks as follows:

> *The terms optimality or balance can never be applied to a network as there is no single evaluation or reference point. The role of the network is different for all its members and also in relation to all other networks connected to it.[…] There is no 'invisible hand' creating a situation of efficiency and health. Instead there are several 'visible hands' that try to create situations that are beneficial to themselves.*

The IMP Group has been holding annual international conferences since 1984, but its origin goes back further. In the 1970's a group of Swedish scholars developed an alternative approach to industrial marketing. Mattsson and Johansson (2006) noted that the reason why research on industrial marketing found such fertile ground in Sweden, was due to the openness of the Swedish business community, which allowed scholars to access 'sensitive' primary data, and thus made in-depth case studies possible.

In the 1970's industrial marketing was still viewed as an extension of consumer marketing. Consequently, the models intended for consumer marketing were considered adequate for industrial marketing as well (Håkansson and Ōstberg, 1975; Mattsson and Johansson, 2006; McLoughlin and Horan, 2002, Sousa, 2010). The new approach proposed by Håkansson and Ōstberg (1975) presents Industrial Marketing as a series of interactions between the customer firm and supplier firm, characterized by power/dependence relationships which evolve in accordance with social exchanges and the extent of mutual adaptations that the two counterparts make.

Subsequent research in the years 1976-1982 constitutes the first phase of the IMP research, in which a growing number of scholars from outside Scandinavia participated (Håkansson and Ford, 2011; Mattsson and Johansson, 2006; McLoughlin and Horan, 2002). The primary unit of analysis was the dyadic relationship between buyers and suppliers. This research period culminates with the development of an Interaction Model (Håkansson, 1982) in which interaction processes and relationships are the core concepts.

The Interaction Model

Axelsson (2010) describes the Interaction Model as consisting of four main groups of variables:

- the interaction process (the interaction processes take part in relationships that can be new/old, or having a history of small/major adaptations);
- the characteristics of the involved parties (e.g., marketing and purchasing strategies of the involved parties, their respective organizational designs, the involved individuals and their aims);
- the atmosphere that surrounds and is part of the relationship (e.g., the degree of cooperation/conflict, trust/distrust, power/dependency between the parties); and
- the environment as the outer context in which the interaction takes place (e.g., a stable/dynamic setting, or domestic/international in scope).

Axelsson (2010: 10) lists three critical issues of the Interaction Model: 1/ the model's relatively limited focus on individuals involved in business, their interpretations and actions; 2/ the model's static view of business practice; 3/ the model's lack of attention to the environment outside of the dyadic relationships.

The last critical issue has spawned the development of the Actors-Resources-Activities (ARA) model, which describes business-to-business markets as interwoven networks of Actors, Resources and Activities, incorporating the environment in which the interfirm relationships are embedded.

The Actors-Resources-Activities (ARA) Model

The ARA network model (Håkansson and Snehota, 1995) can be seen as the outcome of the second phase of IMP research carried out in the years 1985-1995 (Axelsson, 2010; Håkansson and Ford, 2011). In the terminology of the ARA model, the actors are referred to as 'actor bonds', the activities are 'activity links', and the resources are 'resource ties' (Håkansson and Snehota, 1995). The primary unit of analysis are the network relationships. Sousa (2010: 430) describes the main assumptions of the ARA model as follows:

> *Actors (individuals, business units, or firms as a whole) perform activities via deployment of directly and/or indirectly controlled resources (i.e., resources owned by the actors and/or resources accessed or explored via business relationships with other actors). All three layers (actors, activities, resources) are interrelated.*

A firm's total resources are small compared to the sum of the resources that the network's actors hold and control together (Axelsson, 1987). Information and knowledge are conceptualized as resources, but the information exchange can also be conceptualized as an activity during which network organizations create, share, exchange and use information and knowledge.

Therefore, the ARA model can be used to study information and knowledge as resources embedded in exchange activities (Denize and Young, 2007). The criticism of the ARA model is similar to that raised against the Interaction Model. Axelsson (2010: 24) sums up the criticisms in four points: 1/ the ARA model provides a static model of business practice. The interpretations of the involved actors are not considered; 2/

the model deals primarily with manufacturing industries, whereas in the current economic environment, services play an increasingly important role; 3/ the model discusses functions and resources, but rarely translates this in monetary forms; 4/ the ARA model is not synchronized with the Interaction Model.

The co-author of the ARA model, Håkansson (2009) points out that the ambition of the ARA model was not that the model should be testable in empirical studies. The model's contribution is that it has identified three specific layers in business relationships, and their mutual interdependence, thus providing a frame of reference for study of business network relationships. Similarly, Axelsson (2010) notes that the model is useful as a diagnostic tool. The researcher can put an equal weight on all three layers, or he may choose to put the primary focus on just one of the three layers, in which case the other two layers are still operating but in the background.

IMP research (1995 - onwards)

Suggestions for future IMP research pertain particularly to the actor layer of the ARA model and to making the IMP models more dynamic. For example, Axelsson (2010) advocates that the 'atmosphere' components of the Interaction Model (e.g., actors' perceptions of trust/distrust, power/dependency, or cooperation/conflict) should be incorporated into the ARA Model, thus reflecting actors' experiences of what goes on in various relationships. Lenney and Easton (2009) propose that the ARA model should be extended to include the concept of commitment so as to make actors' intentions visible.

The IMP scholars agree that proposals for new research agendas do not mean that the IMP network approach is nearing the end of its 'life cycle' (Lowe and Hwang, 2012), but that IMP research needs to explore new ways of looking at interaction processes and relationships. After all, as pointed out by Axelsson (2010), adaptations and modifications of research models are consistent with some of the core findings from studies of product development in business networks.

Summary Section 2.4.2

Although the present thesis does not focus on social relations at the network level, an overview of key network level research is useful because, as Borgatti and Foster (2003: 1001) note, in network research the micro and macro levels of analysis can be similar both theoretically and methodologically. The similarities are manifest in the properties of structural holes and network closure which are not unlike the properties of weak and strong ties operating at the interpersonal level.

The development of the IMP Group research is interesting geographically and conceptually. Geographically, because the IMP Group evolved from a Scandinavian initiative to a fully-fledged European Group, with a growing research interest from Australia and New Zealand. Conceptually, for two reasons. Firstly, because the IMP research focuses on customer/supplier relationships, with the dyadic relationship between the customer and supplier firm as the unit of analysis. Secondly, because the proposals for future research of the IMP Group relate to relationships at the micro-social level of the firm. The shift in research to focus more on the actor layer of the ARA model, with the aim to reflect on the actors' experiences in "what goes on in various relationships" (Axelsson, 2010), coincides with the case study approach adopted in the present thesis to investigate and explain the information relationships between the individuals working in three specific functional areas of customer and supplier firms in the FFE of NPD.

2.4.3 Social relations at the interpersonal level

In the context of the FFE of NPD the interpersonal social networks consist, inter alia, of social ties between the employees of the customer and supplier firms participating in NPD activities where the social ties function as conduits for the exchange of information and knowledge (Granovetter, 1973, 1983).

Size and tie strength are the most important characteristics of social networks. The network size can be actual (i.e., the number of ties an actor has), or effective (i.e., the extent to which the actor's own contacts know - are connected to - each other). A person's effective network size is larger when the people he or she is connected to do not know each other (Anderson, 2008). The other characteristic of social networks is the tie strength which indicates the closeness of a dyadic relationship.

Tie strength

The interaction intensity of social ties between the actors ranges from strong to weak. Granovetter (1973: 1361) defines the strength of ties as follows:

> *The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie.*

Researchers studying the role of social ties in the transfer of knowledge (e.g., Bstieler and Hemmert, 2008; Cross and Sproull, 2004; Fliaster and Spiess, 2007; Hansen, 1999; Kijkuit and Van den Ende, 2007; Krackhardt, 1992; Levin and Cross, 2004; McEvily and Marcus, 2005) have started with the Granovetter's definition of tie strength, but they have also refined and expanded the definition further. The next paragraphs summarize the main characteristics of the two extremes of the tie strength spectrum as deployed by the above authors.

Strong ties

Strong ties are close interpersonal relationships, often within a small group of actors, such as the (Design) Engineers in NPD teams. Strong ties prefer to engage in the transfer of internal information (i.e., information that is firm-specific often involving tacit complex knowledge). By implication, this means that strong ties are better in incremental innovations, which rely on extant internal knowledge, rather than in radical innovations for which acquiring knowledge from outside sources is often necessary. Trust among the exchanging parties in a strong tie relationships is taken for granted, and the exchange of information and knowledge is reciprocal. Strong ties are good at implementation and cooperation because they are willing to be of assistance, and to share knowledge with their group. Therefore, the environment of strong ties is conducive to learning. In the long run, however, learning can be hampered by knowledge redundancy (i.e., overlapping knowledge), and by the reluctance of strong ties to trust information that comes from outside the firm, known as the Not Invented Here (NIH) syndrome (Katz and Allen, 1982).

A slightly dissenting view on strong ties has recently been presented by Fredberg and Piller (2011) who base their findings on their seven year longitudinal case study of the sports shoes manufacturer Adidas. Since the study concerns customer (and not supplier) involvement in NPD, it falls outside the scope of the present thesis. However, the Adidas case is nevertheless interesting because it brings nuance to the traditional strong tie - weak tie dichotomy. The authors argue that strong ties with customers can result in breakthrough innovations, provided that the customers themselves are fully integrated in the development process, instead of only responding to it. The example given is that of the 'Tunit' modular shoe system introduced in 2006. The 'Tunit' system allowed the user to customize his/her shoe after the purchase of the necessary shoe components which were all interchangeable. By 2006, input from users was considered a crucial source of innovation in the performance division of Adidas. In hindsight, the Adidas case confirmed the long established ability of strong ties for implementation and cooperation. By fully integrating the customers into the development process, the customers effectively became strong ties.

Weak ties

Weak ties are distant interpersonal relationships typified by infrequent interaction. Weak tie relationships lead to novel diverse (i.e., non-redundant and/or heterogeneous) information.

This information is usually codified and therefore easy to transfer. Connecting with weak ties is time-efficient because there is no expectation of reciprocity, and therefore, the relationships with weak ties are less costly to maintain. Weak ties can be instrumental in the diffusion of ideas, but they are less suited for the implementation of ideas because of the disconnectedness between weak ties, and their temporary character (i.e., infrequent contacts).

Comparing strong and weak ties, Granovetter (1973) explains that strong ties operate on the principle of homophily, that is, the tendency of people to connect to groups of people that are similar to them. Given the heterogeneity in the population, weak ties are more numerous. As Granovetter (1982: 107) puts it:

> *In the evolution of social systems, perhaps the most important generator of weak ties is the division of labour, since increasing specialization and interdependence result in a wide variety of specialized role relationships, in which one knows only a small segment of the other's personality.*

In the context of NPD, the heterogeneity is reflected in the number and range of disciplines that the increasing complexity of products necessitates. Heterogeneity in NPD, and thus the presence of weak ties, is further compounded by job mobility and the easy connectivity enabled by IT technology (Barczak et al. 2007, 2008; Constant et al., 1996; Haythornthwaite, 2002). However, scholars differ in their views on whether IT technology is a suitable substitute for face-to-face contacts, and the transfer of information and knowledge. Lawson et al. (2009) warn against the trend to rely on virtual connectivity in NPD, and thus, underestimating the value of face-to-face interactions through social ties and relationships. On the other hand, Borgatti and Cross (2003) while recognizing the importance of face-to-face-interactions, accept virtual work as an alternative way of developing relational conditions for accessing and exchanging knowledge. The relational character of the information and knowledge exchange in NPD has been underscored by the research of Ganesan et al. (2005).

Their survey among firms in the US optics industry found that whereas e-mail communication resulted in the acquisition of knowledge that enhanced NPD outcomes, such as speed and creativity, frequent face-to-face communications, enabled by close geographic proximity of the firms, were not related to NPD-related knowledge acquisition. Ganesan et al. (2005) suggest that a major factor in the acquisition of NPD-related knowledge is not the geographic proximity but the strength of relational ties between the firms, and therefore, the firm's relational ties should be cultivated irrespective of spatial location.

Strength of Weak Ties

Mark Granovetter (1973, 1982) is best known for his concept of the Strength of Weak Ties. The strength of weak ties (e.g. acquaintances) lies in their ability to access new and diverse information, and to enable the flow of information from one social circle to another, whereas strong ties (e.g., friends and family) cannot perform this bridging function. Thus, according to Granovetter (1982: 106):

> *Individuals with few weak ties will be deprived of information from distant parts of the social system, and will be confined to the provincial news and views of their close friends.*

Granovetter points out that weak ties are not automatically bridges, but that all bridging ties are weak ties.

The concept of a 'bridge' is defined as a line in a network that links two actors who are not otherwise connected (Granovetter, 1973: 1364-1366). Granovetter (1982: 108) further notes that given the heterogeneity of bridging weak ties, and the diversity and novelty of information to which they provide access, the individuals who handle bridging weak ties must possess, or develop, intellectual and cognitive flexibility.

In the context of NPD, the intellectual and cognitive flexibility is manifest in the ability of (Design) Engineers to continually adapt their search for design solutions to changing design conditions through a comparative analysis of interim findings, the so-called 'muddling through' process (Kopecka et al., 2012). An essential element in this process is the use of social relationships in the interaction with diverse functions and disciplines in order to access heterogeneous information, and so to arrive at creative solutions (Perry-Smith and Shelley, 2003; Fliaster and Schloderer, 2010).

Lin (2001: 67-68) observes that until 1973, when Granovetter first introduced the concept of the Strength of Weak Ties, most research focused on the strength of strong ties. Based on the homophily principle, strong ties were studied for their positive features from which social groups derived benefits, such as group collaboration, cohesion, and satisfaction. Weak ties were ignored because they were seen as the opposites of strong ties; the bridging function of weak ties between two groups of actors went unrecognized.

Combinatory benefits of strong and weak ties

The review of the characteristics of weak ties and strong ties shows that the effect of social ties on the exchange of information and knowledge can be positive, but that it can also have its drawbacks. With the growing recognition that the optimal transfer and use of information and knowledge is a central capability of the firm (Zander and Kogut, 1995), researchers turned their attention to the ways in which to combine the benefits of strong and weak ties. The next paragraphs outline the most pertinent research on the subject by Hansen (1999), Hansen et al. (2001), and Levin and Cross (2004). The three examples have been chosen because they relate to two core concepts of the present thesis, namely, to new product development and to information relationships.

Hansen (1999) & Hansen et al. (2001)

Hansen (1999) in his study of 120 NPD projects undertaken by 41 divisions in a large electronics company studied the effect that social ties among the divisions and their employees have on project completion time. The study reported that weak ties were particularly effective during 'information and knowledge search' activities in NPD projects, whereas strong ties were necessary for the 'information and knowledge transfer' activities. Linking the tie strength to knowledge complexity, Hansen (1999) further found that weak ties were only helpful in transferring codified knowledge, but hampered the transfer of complex knowledge for which closer interaction between the knowledge provider and knowledge recipient was an important enabling condition.

Thus, the completion time of a NPD project was found to be contingent on the knowledge complexity that was transferred across the divisions. The study further concluded that given the fact that the activities of 'search and transfer' of information and knowledge in NPD were intertwined, the NPD team should consist of people with both weak tie and strong tie capacities.

In a follow-up research, Hansen et al., (2001) studied the conditions under which social ties were beneficial to, or hindered, the completion of work tasks. The study focused on how the time and effort that were needed to maintain social ties affected the completion of diverse work tasks. Hansen et al. (2001) made a distinction between exploration and exploitation work tasks (March 1991), where the explorative work related to radical innovation, and the exploitation work related to incremental innovation. The level of analysis were NPD teams consisting of Project Managers and Project Engineers who participated in 98 NPD projects in a large multidivisional electronics and computer company. The main finding of the study was that different work tasks used different network structures to complete a project.

The exploration work tasks were less well defined, and therefore, to complete the project, the teams made use of a network consisting of a large number of strong external ties that were non-redundant; i.e., their knowledge did not overlap. The teams turned to strong ties because these ties were good at transferring tacit knowledge, easy to access, and willing to help. The norm of reciprocity, inherent in strong tie relationships (i.e., helping a person with the expectation that that person will return the help when needed) was beneficial for the exploration work tasks because it enabled the team to have quick and repeated access to information and consultation without restrictions in time.

In contrast, the exploitation work tasks were well defined, and therefore, the teams could fall back on existing knowledge, or used weak ties to complete the project. The use of strong ties with their norms of reciprocity was found harmful for the exploitation work tasks because the team needed only complementary explicit knowledge, e.g., acquiring a software programme developed elsewhere instead of developing it anew. Moreover, the exploitation work teams found that complying with the norms of reciprocity was time consuming and outweighed the knowledge benefits. In fact, all teams experienced a negative effect on completion time when they engaged in reciprocal helping activities.

This finding resembles the research concerning whether or not supplier involvement in NPD will speed up the NPD process. Several scholars (Primo and Amundson, 2002; Song et al., 2006) reported that involving suppliers in NPD had actually delayed the NPD process because of a need for greater coordination between the supplier and customer firm. Relating these findings to the research of Hansen et al. (2001) and the issue of reciprocity, it could be argued that coordination involves elements of reciprocity in the sense that coordination requires, and is dependent on, extra communication effort (and time) between the parties that are being coordinated.

Levin and Cross (2004)

Levin and Cross (2004) investigated whether, and why, strong or weak ties provided more useful knowledge and contributed to knowledge sharing. The receipt of useful knowledge was studied at the dyadic level of analysis involving 127 employees within three divisions of three different firms (a pharmaceutical company, a bank, and an oil and gas company) in three countries. The term 'receipt of useful knowledge' was used to indicate that the received knowledge had a positive impact on a knowledge seeker's work. Levin and Cross (2004) proposed that knowledge sharing was contingent on three characteristics, namely:

- the structural characteristic of tie strength (weak or strong) between the knowledge seeker and the knowledge source;
- the relational characteristic of perceived trustworthiness of the knowledge source; and
- the characteristic of knowledge complexity (tacit or explicit).

In conceptualizing trustworthiness, Levin and Cross (2004) were guided by the empirical research on trust by McAllister (1995) and the integrative model of dyadic trust developed by Mayer et al. (1995). Levin and Cross (2004) conceptualized trustworthiness as a two-dimensional construct consisting of two types of trust: benevolence-based trust and competence based trust.

Benevolence-based trust assumes a positive orientation of the knowledge seeker toward the knowledge source. When seeking knowledge, the seeker becomes vulnerable to the benevolence of the knowledge source. Benevolence-based trust implies that the knowledge seeker can be sure that the knowledge source will keep in mind the seeker's interests. For example, the knowledge source will see to it that the seeker is not harmed or damaged, and that the seeker has the feeling that the knowledge source cares about what happens to the seeker.

Competence based trust assumes that the knowledge seeker believes that the knowledge source approaches his/her job with professionalism, and that given the knowledge source's track record, there is no reason to doubt the knowledge source's competence.

The study's findings indicated that the more knowledge transfer involved tacit knowledge, the more crucial competence-based trust became. Levin and Cross (2004) noted that given the fact that few people could be an expert in many areas, trusting a knowledge source might be even more important than receiving useful knowledge.

The study's main finding was that perceived trustworthiness functioned as a mechanism through which strong ties yielded more useful knowledge than weak ties. Strong ties had a positive impact on the receipt of useful knowledge, and this impact was mediated by benevolence-based trust and competence-based trust. However, once the two dimensions of trustworthiness (benevolence and competence) were held constant, the direct impact of strong ties on the receipt of useful knowledge was less than that of weak ties. This finding is consistent with the concept of the Strength of Weak Tie (Granovetter, 1973, 1982), which states that strong ties provide the relational benefit of trustworthy information, but do not have the structural benefit of weak ties to access non-redundant information.

As a result of this finding, Levin and Cross (2004) proposed a new hybrid concept of social tie, the 'trusted weak tie' with the relational benefits of strong ties (trust) and the structural benefits of weak ties (access to non-redundant information). Levin and Cross (2004) argue that since weak ties are less costly to maintain (with no reciprocity in information relationships expected), developing trusted weak ties in organizations, for example, by training and assessing trustworthy behaviour of employees, is a relatively inexpensive way to make the transfer of knowledge in organizations more effective.

Taking into account the concept of trusted weak ties (Levin and Cross, 2004), and looking back in hindsight at the case study by Hansen et al. (2001), it could be argued that when the teams in the case study (Hansen et al., 2001) were "seeking strong external ties that were non-redundant, (This requirement is in itself a contradiction given that the property of strong ties is that they show an overlap in knowledge), the teams were in fact seeking trusted weak ties. However, at the time of writing the case study (Hansen et al., 2001), the concept of trusted weak ties (Levin and Cross, 2004) has not yet been known.

The present thesis has applied the concept of trusted weak tie in the Conceptual Framework, shown in Figure 3.3 in Chapter 3.

Summary Section 2.4.3

Strong ties and weak ties can be viewed as single effect mechanisms that enable the processes of the exchange and the utilization of information and knowledge to take place. The single effect of strong ties is manifest in the utilization of information and knowledge, and can be attributed to the implicit trustworthiness of strong ties. The single effect of weak ties is manifest in the access to novel and diverse information and knowledge and can be attributed to the heterogeneity of information contacts. The concept of trusted weak ties holds out a promise of uniting these two distinct processes. However, this combinatory effect raises a question of whether the access of information and knowledge mediated by a trusted weak tie will be directly followed by the utilization of that information and knowledge. In other words, to what extent are the processes of access and utilization sequential?

Therefore, the Research Questions of the present thesis will seek answers about why some information exchanges in the FFE of NPD result in the utilization of supplier information and knowledge, while other do not.

2.4.4 The relational view of social ties

The research studying the role of social ties in information and knowledge transfer has mostly adopted a structural view of social ties, thus focusing on the tie strength, or on the configuration of networks, that is, the location of actors within a network, and the advantages arising from that location. Less research attention has been paid to a relational view of social ties, that is, to the content of social ties. The tie content refers to the resources being exchanged, such as money, materials, advice, and knowledge (Powell and Smith-Doerr, 1994; Galaskiewicz, 2011).

Several authors have called for more research on interpersonal transfer processes in social networks. For example, Borgatti and Cross (2003: 433) state that:

To date, aside from findings relating information seeking to the closeness or strength of a relationship (Granovetter, 1973), we know little about the ways in which kinds of relationships (in contrast to structural properties) condition information flows and learning in networks.

Rodan and Galunic (2004: 543) argue that a structural view of network exchanges needs to be augmented by considering the knowledge held by the actors whose relationships mediate the exchange. Obstfeld (2005: 107) observes that social network theories tend to emphasize the importance of structural knowledge conduits (i.e., tie strength) in accessing new information but overlook the accumulated stock of individual social knowledge resulting from informal ties, such as knowledge about the organization's culture, or knowledge about personal and differing work styles of critical departments within the firm. Similarly, Hansen (1999: 83) notes that:

Most social network research has remained agnostic with respect to the content of what flows through the ties and have not taken into account knowledge complexity.

The distinction that the structural view of social ties makes between tacit knowledge (transferred via strong ties), and explicit knowledge (transferred via weak ties), is helpful in explaining the influence of tie strength on the transfer of knowledge. However, the structural view does not increase our understanding of the relational aspect of knowledge complexity and information relationships. In other words, the structural view doesn't answer questions, such as: When, why, and to whom an information seeker turns for information and knowledge? What makes a particular piece of information or knowledge useful? The research by Borgatti and Cross (2003), Rodan and Galunic (2004), and Cross and Sproull (2004) studied knowledge complexity and information seeking behaviour from a relational point of view.

The present thesis has a similar objective: it will study the utilization of supplier information and knowledge from the perspective of the information relationships between/among the individuals involved. Therefore, the studies by Borgatti and Cross (2003), Rodan and Galunic (2004), and Cross and Sproull (2004) are particularly relevant. The next paragraphs summarize and comment the main findings.

Borgatti and Cross (2003)

In their model of information seeking, Borgatti and Cross (2003) propose that the frequency that a person seeks information from another is a function of four relational characteristics, between the information seeker and the information provider, namely:

- the extent to which an information seeker knows what the person (the information provider) from whom he/she seeks information knows (variable 'knowing);
- the extent to which an information seeker values what that person knows (variable 'value');

- the ability to gain timely access to that person's thinking (variable 'access'); and
- the potential costs of interaction incurred in seeking information from that person in terms of interpersonal risks by admitting ignorance, or obligations to return the help in the future (variable 'cost').

In turn, the actual information seeking experience updates the seeker's perception of the information provider with respect to the four relational characteristics. Thus, Borgatti and Cross (2003) conceptualize information seeking as a dynamic choice process. The model was tested at two different global pharmaceutical organizations in four geographic locations. The unit of analysis was the relationship between pairs of persons; i.e. a dyadic relationship.

The results showed that three of the four relational characteristics - knowing, value and access - consistently predicted the frequency of information seeking, but the cost relation did not. The authors suggest two explanations for this finding. First, that the cost of information seeking functions as a characteristic of a group as a whole, and as such it represents the information seeking culture of the group which affects whether and how often people seek information from others, rather than who is sought out. The second explanation pertains to the choice of dependent variable which was the frequency of information seeking, not the effectiveness of information seeking. The authors suggest that since people work under time pressure, they may seek out information from others out of necessity, regardless of the cost of interaction. Thus, the cost does not affect information seeking, but Borgatti and Cross (2003) surmise that the cost might play a role when the effectiveness of interaction, such as learning, is also being evaluated.

Borgatti and Cross (2003) see the practical benefits of their model as a diagnostic tool with which it is possible to assess and improve information seeking behaviours in teams. One possible application of the model that springs to mind is the FFE of NPD. Future research could use the model of Borgatti and Cross (2003) to analyse the information seeking and processing in the FFE of NPD.

The PDMA (Product Development Management Association) survey of 416 larger goods manufacturers in the US (Barczak et al., 2009) found that only 60-65% of the ideas that were generated were formally recorded, and less than half of the ideas were made searchable by some other than the idea generator. By applying the relational perspective of information seeking behaviour to the FFE of NPD, more could be learned about why the generated ideas were so inadequately stored and disseminated.

Rodan and Galunic (2004)

Rodan and Galunic (2004) studied how the relationship between knowledge heterogeneity in social networks and network structure affected the overall managerial performance and managerial innovation performance. The study involved 106 Product/Project Managers from a medium-sized Scandinavian telecommunications company. The participants were first asked to assess the structure of their network: how well did their network contacts know each other? Were the contacts connected or disconnected to each other (network density or network sparseness)?

Next, the participants were asked about the content of their network. The participants assessed the similarity and dissimilarity between their network contacts' domain of knowledge and expertise (knowledge heterogeneity). Rodan and Galunic (2004) made a further distinction between two kinds of knowledge heterogeneity: the 'surface' information in the form of news and gossip, and the deeper 'know-how' in the form of expertise knowledge.

The study found that both the network sparseness (i.e., the existence of structural holes created by disconnectedness of contacts in the manager's network), and knowledge heterogeneity contributed to the overall managerial performance because they enabled access to diverse (non-redundant) sources of knowledge. However, knowledge heterogeneity had more impact on managerial innovation performance. Rodan and Galunic (2004) observe that:

> *While knowledge diversity is more likely to come from disconnected contacts, knowing the structure of a manager's network does not tell us everything we need to know about the distribution of knowledge within it. In other words, there is no guarantee that by building a sparse disconnected network, a manager will also be gaining access to heterogeneous knowledge.*

What follows from this observation is that when managers build their network of structural holes, the managers should give greater priority to contacts that provide heterogeneous information and knowledge over contacts that only provide access to non-redundant knowledge. Both types of contacts cost time and effort to maintain, but the contacts with heterogeneous knowledge help the manager to ideas conducive to creativity and innovation. Rodan and Galunic (2004) cite the example of IDEO, a California based product development consultancy, which has a policy of including heterogeneous sources of knowledge when generating new ideas.

Rodan and Galunic (2004) further suggest that in practice, managers can encourage the bridging of structural holes and the access to heterogeneous knowledge by introducing the policy of job rotations and co-locations. Such policy would require employees to spend time in diverse functional areas of the firm, or at the supplier firms in order to build ties to people with different expertise.

In the literature on supplier involvement in NPD, the benefits of co-location (Twigg, 1998; Lakemond et al., 2006; Liker and Choi, 2004; Petersen. 2003; Schiele, 2012; Wagner and Krause, 2009), and the benefits of heterogeneous knowledge in NPD (Bonner and Walker, Jr., 2004; Knudsen, 2007; Lau et al. 2010) are familiar themes. Although not always coached in the terms of social network theory, the message is similar, and shows that scholars increasingly view NPD as a social process.

Cross and Sproull (2004)

Cross and Sproull (2004) developed a concept of 'actionable knowledge' which they defined as "knowledge that leads to immediate progress on a current assignment or project". They emphasize that information relationships between the information seeker and the information source are instrumental in the way information and knowledge are used. In their emphasis on the interpersonal relationship Cross and Sproull (2004) follow in the footsteps of Rogers (1983) and his theory of Diffusion of Innovations in which the information-exchange relationship (i.e., the dyad between the sender and recipient) plays a central role.

Cross and Sproull (2004) proposed five components of actionable knowledge which they validated in the information seeking behaviour of 40 managers of a Big Five accounting firm in the US. The five components of actionable knowledge that help people solve their problems at work are:

- Solutions (Informants seek from information source answers to questions about 'know-what' and 'know-how';
- Referrals (Informants receive from information sources pointers to databases or other people);
- Problem reformulation (Informants approach information sources for help with re-defining problem dimensions);
- Validation (Informants turn to information sources to validate their ideas. Informants seek assurance that they are thinking along the right lines); and
- Legitimation (Informants seek to justify their understanding of ideas by turning to influential people in other contexts).

The study found that 95% of informants obtained all components of actionable knowledge from their three most important information relationships, but no more than three components came from one person.

This finding suggests that information seeking is a multidimensional activity involving multidimensional information sources.

Another finding of the study was that information relationships between the information seeker and information source influenced who was sought out for which component of actionable knowledge. For example, in cases of referrals, problem reformulation and validation, the information relationship between the seeker and information source was closer than in cases when the seeker had a well-defined problem to which the solution could be obtained from diverse sources.

Cross and Sproull (2004) suggest that being aware of the five components of actionable knowledge enables managers to better supervise knowledge sharing among employees. Cross and Sproull (2004) conclude that investing in social networks as sources of actionable knowledge can lead to more collaborative environments than investing in IT technologies and procedures.

The implicit argument here is that the existence of IT technology in itself does not guarantee the transfer of knowledge. The data held in an IT system become information when a human being puts them into context (i.e., gives the data a meaning). The thus created information only becomes knowledge when it results in human action (Davenport and Prusak, 1998). The concept of actionable knowledge through social networks is particularly relevant in the light of recent research on NPD information management systems which showed that the current systems were "woefully inadequate to handle the full information needs of NPD teams" (Zahay et al, 2011:500).

Social ties in NPD

The research on social ties in NPD is recent. Social ties have been conceptualized in the research on buyer-seller relationships as antecedents of commitment (Stanko et al., 2007), as facilitators of knowledge acquisition in NPD alliances (Bstieler and Hemmert, 2008), and as social mechanisms that contribute to the exchange of information and knowledge between customer and supplier firms (Lawson et al., 2009). The next paragraphs summarize and discuss these three studies and their relevancy to the present thesis.

Social ties and commitment

Stanko et al. (2007) translated the four dimensions of tie strength (i.e., relationship length, mutual confiding, reciprocal services, and emotional intensity), as defined by Granovetter (1973), into the context of customer/supplier relationships. The decision to draw on the concept of tie strength (Granovetter, 1973, 1982) was inspired by the fact that the concept incorporates both behavioural dimensions of relationships (e.g., length of relationship, mutual confiding, and reciprocal services) and an affective dimension of relationships (e.g., emotional intensity).

The study examined the effect of tie strength on the way a customer firm shaped its commitment to a supplier firm. Stanko et al. (2007) defined the commitment to the supplier firm as the degree of effort and intention shown by the customer firm to develop and maintain a stable, long-term relationship with the supplier into the future.

The study further examined how the commitment of the customer firm to its supplier firm affected the customer firm's purchase behaviour, and the likelihood that the customer firm would gain the status of a 'favoured' customer from the supplier firm. A supplier firm considers a customer firm as 'favoured' when the customer firm purchases products frequently, steadily, and in high volumes, and takes steps in keeping purchasing costs low, all of which enables the supplier firm to better plan its production, inventories, sales and support (Bonner and Calantone, 2005). The concept of 'favoured' customer' is similar to the concept of 'preferred customer' developed by Schiele (2006, 2010), discussed in Section 2.2.1.

The study's informants were 119 Purchasing Managers from firms in the industrial manufacturing, electronic equipment, transportation equipment, and hospital industries. The average relationship length between the customer and supplier firms was 13.7 years.

The Purchasing Managers had on average 10.5 years of experience. The study focused on customer/supplier relationships, which met the following criteria:

- the supplied product was costly and 'mission-critical' for the customer firm;
- the purchase process required the involvement of several people in the customer firm; and
- the supplied product constituted a significant budgeted expense for the customer firm.

When translating the dimensions of tie strength into a business relations context, Stanko et al. (2007) took as a departure point the definition of tie strength by Granovetter (1973: 1361):

> *The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie."*

and stipulated that:

- 'Time' refers to the relationship length (a behavioural dimension). Over time, with repeated contacts, customer/supplier relationships grow in strength and in trust;
- 'Emotional intensity' (an emotional dimension) refers to the degree to which partners have feelings for each other beyond the economic transaction. ("We would feel bad if our firm switched away from this supplier for this type of product"). It represents the strength of emotional bonds ("This manufacturer means more to us than the product they provide us. Their products create excitement within our organization.");
- The 'intimacy', or 'mutual confiding' (a behavioural dimension), refers to sharing of fine grained, sensitive, and confidential information through both formal and informal channels of communication ("We regularly provide this supplier with long-range forecasts of product requirements."); and
- 'Reciprocal services' (a behavioural dimension) refer to the extent that the parties take active responsibility for the partner's well-being, as well as their own. There exists a unity of interest and solidarity. Problems are solved jointly.

In testing the effect that the four dimensions of tie strength had on the shaping of commitment of the customer firm toward the supplier firm, the study found that three of the four tie dimensions (i.e., emotional intensity, mutual confiding, and reciprocal service) were positively related to the shaping of commitment. In contrast, the relationship length was not related to commitment. Stanko et al., (2007) attribute this finding to the fact that in business-to-business relationships, suppliers are continuously monitored, regardless of how long the relationship has been in place.

The study concludes with a recommendation to management to make the development of behavioural and emotional dimensions of relationships an integral part of the firm's vision and strategy. Thus, employees should be made aware of, rewarded for, and empowered to build behavioural and emotional bonds with key customers.

The present thesis has applied Stanko's translation of the dimensions of tie strength in the Cross-case Analysis (in Chapter 8, Section 8.3.1) of one of the four Multicase Themes that emerged from the case study data. The Stanko's dimensions of tie strength are used by way of a peer review reference in order to enhance the credibility of the case study findings.

Social ties and knowledge acquisition in NPD alliances

The study of Bstieler and Hemmert (2008) is similar to the study by Stanko et al. (2007) in that it also investigates the mediating effect of tie strength in relationships between customer and supplier firms. The context and objectives of the study are different, however. Bstieler and Hemmert (2008) investigated the influence of tie strength on knowledge acquisition in NPD alliances among firms in the South Korean manufacturing industry. The study's participants came from 165 machinery and 147 electronics firms that had 50 or more employees. The informants were Heads of Engineering or R&D. The reason for the study was that the authors observed that many NPD alliances often failed because of transactional uncertainties, and that the failure originated in uncertainties in the knowledge transfer between alliance partners; i.e., the relational content of social ties.

Bstieler and Hemmert (2008) propose the concept of tie strength as a means with which to counter this problem. Bstieler and Hemmert (2008) posit that if the firms in a NPD alliance are to function well, they need to have more information about the partner's goals, expectations and intentions, so as to be better able to predict or influence the other partner's behaviour.

Therefore, a strong tie relationship between the alliance firms can help reduce transactional uncertainty in inter-organizational knowledge transfer. Strong tie relationships are particularly relevant in South Korea. Most Koreans believe that they are in a disadvantage when dealing with external organizations, which is the reason why they nurture extensive social relationships that go beyond family ties. Bstieler and Hemmert (2008) further note that firms do not necessarily cooperate only within the network of strong ties. Following up on the research on weak ties by Levin and Cross (2004) and Rindfleisch and Moorman (2001), Bstieler and Hemmert (2008) investigated the benefits that weak ties might bring to NPD alliances. They concluded that while strong ties were expected to foster knowledge acquisition, weak ties could be equally effective in transferring and acquiring knowledge, on condition, that appropriate relational mechanisms, such as the quality of communication and perceived fairness had been established.

The idea to incorporate a relational mechanism into the functioning of weak ties is similar to the concept of trusted weak tie, introduced by Levin and Cross (2004). The difference is that whereas in the concept of trusted weak ties the 'relational mechanism' is benevolence-and –competence-based trust which operates at the interpersonal dyadic level, the relational mechanisms proposed by Bstieler and Hemmert (2008) are communication quality and perceived fairness which operate at both the inter-firm and intra-firm level. Bstieler and Hemmert (2008) refer to the two relational mechanisms as behavioural factors.

The overall finding of the study is that the behavioural factors (i.e., communication quality and perceived fairness) play a more prominent role in knowledge acquisition in NPD alliances than the strength of ties. Bstieler and Hemmert (2008) conclude that when firms collaborate with relative unknown partners whom they met, for example, through a trade show, behavioural factors may function as substitutes for strong ties. This finding is consistent with the research on 'swift trust' (Meyerson et al., 1996) which posits that temporary groups, or groups at the beginning of their collaboration, that had not yet time to develop trust, but nevertheless need to work together on complex interdependent tasks, substitute trust by a quick assessments of partner's behaviour.

Social ties as social mechanisms

The study on knowledge sharing in customer/supplier cross-functional NPD teams (Lawson et al., 2009) conceptualizes social ties as informal socialization mechanisms and compares them with formal socialization mechanisms, such as cross-functional teams, matrix reporting structures, co-location, or regular supplier team meetings.

Lawson et al. (2009) note that informal socialization mechanisms are sometimes referred to as 'socialization tactics', but that they in fact play an important role in knowledge transfer. Citing Cousins et al. (2006), the study recounts the story behind the design of a new vehicle at the Design Center in Bloomfield Hills, Michigan.

The building provides lots of open floor space to park test vehicles, and to encourage informal discussions between buyers, engineers and suppliers. But the building has no elevators because 'people often do not talk in elevators'. Instead, the building has escalators between the floors.

Another example of an informal socialization mechanism is shown in the practice of a Japanese manufacturer who visits supplier sites prior to embarking on a NPD project; i.e., in the fuzzy front end of NPD. The visits to supplier sites and the following discussions help the Japanese manufacturer to assess the suppliers' ability to join the NPD team. It is only after such a series of visits that the supplier is requested to submit an initial design proposal.

Lawson et al. (2009) proposed a theoretical model with which to test the impact of formal and informal socialization mechanisms on the level of knowledge sharing within inter-organizational NPD projects, and the subsequent effect on customer firm performance. The participating firms were drawn from a database held by the

Chartered Institute of Purchasing & Supply (CIPS) in the UK. In all, 111 manufacturing firms took part in an Internet-based survey.

The study found that higher level of knowledge sharing improved supplier-led product development outcomes, which in turn improved firm-level NPD performance and, ultimately firm's financial performance. The study findings further suggested that formal socialization mechanisms, such as cross-functional teams, provided the structure for interaction, but that it was the informal socialization mechanism, such as social ties, that defined the roles and processes involved in knowledge sharing between the customer and supplier firm.

The goal of the present thesis is similar to the study of Lawson et al. (2009) in that it also focuses on informal inter-organizational exchanges of information and knowledge in the course of collaborative NPD between supplier and customer firms. The differences lie in the following aspects:

- level of analysis (the NPD project versus the micro-social level of the firm in the FFE of NPD);
- research sample (111 manufacturing firms in the UK versus 4 firms in the Netherlands);
- research design (single respondent survey representing the customer firms versus case studies representing respondents from both customer and supplier firms);
- research objective (the financial performance of the customer firm versus the utilization of supplier information and knowledge in the FFE of NPD).

Summary Section 2.4.4

The cited literature indicates that in order to increase our understanding of the exchange of information and knowledge, and their utilization, it does not suffice to take a structural view of social ties; i.e., to only study the way the parties engaged in the information & knowledge exchange are connected to one another. Such research needs to be supplemented by a study into the content of the information and knowledge exchange process; i.e., the type of information and knowledge exchanged as well as the relationship between the exchange partners, and the designated objective of the exchange.

The exchange of information and knowledge through informal social ties can no longer be regarded as a peripheral activity of a handful employees. On the contrary, informal ties run parallel to the official structures set up for information exchange, and are frequently more effective. Both the formal and informal social ties represent information relationships. Therefore, the Research Questions in the present thesis will seek answers about what constitutes an information relationship in the FFE of NPD between the individuals in the three functional areas of customer and supplier firms; i.e. (Design) Engineers, Purchasing, and Sales Engineers.

2.4.5 Conclusion of Part Four

The literature on the role of social relations in the exchange of information and knowledge (shown in the last two columns in Figure 2.1) observed a number of concepts that are relevant to the subject of the present thesis.

Firstly, the concept of embeddedness (Granovetter, 1985; Uzzi, 1996, 1997), which holds that all economic actions are embedded in social relationships, that is, are shaped and constrained by interpersonal relationships. The concept of embeddedness can be translated into the FFE of NPD context as follows:

> *The interpersonal relationships in the FFE of NPD are made up of formal and informal social ties between the employees of the customer and supplier firms participating in NPD activities.*

Secondly, the concept of social ties as conduits for the exchange of information and knowledge (Granovetter, 1973, 1982). The social ties have structural or/and relational properties that can be found in three types of ties. Strong ties possess relational properties, such as trust, sharing of information and knowledge, and learning. Weak ties are endowed with structural properties to access novel and heterogeneous information. Trusted weak ties, a concept developed by Levin and Cross (2004), are a hybrid type of a social tie that combines the relational and structural properties of strong ties and weak ties. Trusted weak ties are based on competence-and- benevolence-based trust. The literature review revealed that all three types of ties can function as social mechanisms in the exchange of information and knowledge. Therefore, the ties have been incorporated in the Conceptual Framework shown in Figure 3.3 in Chapter 3.

Thirdly, the concept of 'actionable knowledge', defined as "knowledge that leads to immediate progress on a current assignment or project" is relevant to the present thesis because it suggests that the exchanged knowledge is utilized only if the knowledge is actionable.

In other words, the exchange of knowledge does not necessarily lead to the utilization of knowledge. This finding may hold a possible explanation for the non-utilization of supplier information and knowledge, and will therefore be given a special attention in the present thesis.

Methodological choices: the unit of analysis and the theoretical background

(The literature review informed the choice of the unit of analysis and the choice of a theoretical background.)

In line with the research of Cross and Sproull (2004) and Borgatti and Cross (2003), the present thesis will adopt a dyadic information relationship as the unit of analysis. The information relationship is conceptualized as a continual dynamic exchange process between the seeker and the provider of information and knowledge, where the seekers are (Design) Engineers and Purchasers of the customer firm, and the provider is the Sales Engineer of the supplier firm.

The choice of the unit of analysis has in turn influenced the choice of the theoretical background against which to study and learn about the dyadic information relationships, and ultimately about the utilization of supplier information and knowledge in the FFE of NPD. The thesis will adopt the theory of the Strength of Weak Ties (Granovetter, 1973, 1982) as its theoretical background because the theory allows to study the dyadic information relationships through the properties of social ties that exist between the parties to the exchange.

The choice of the theory of the Strength of Weak Ties is noteworthy because, as pointed out by Modi and Mabert (2007), most studies on NPD collaborative relationships between customer and supplier firms, explicitly or implicitly draw on the theory of transaction cost economics (TCE) developed by Oliver Williamson (1975). The present literature review found this to be true. The only empirical study to date that focused on supplier involvement in in the FFE of NPD took the TCE theory as its theoretical framework (Wagner, 2012).

Modi and Mebert (2007) further suggest that given the importance of knowledge transfer in improving supplier performance, and the associated investment of human resources, the theory of the knowledge based view (KBV) of the firm might be a better theoretical lens through which to examine supplier involvement in NPD. Here it is interesting to note that the critics of the KBV theory (Argote and Ingram, 2000; Felin and Foss, 2006; Foss, 2007; Foss et al., 2010) argue that the KBV theory pays insufficient attention to the micro-foundations of the firm, that is, to the human resources from which the performance and capabilities of the firm are ultimately derived.

In the present thesis, the theory of the KBV theory is less appropriate because the level of analysis is not the firm but the micro-social level of the firm: the individuals/groups involved in daily exchanging and using of supplier information and knowledge in the FFE of NPD.

2.5 ***Part Five:*** **Literature Synthesis and Research Questions**

Figure 2.4 highlights the areas in the literature that resulted in the underpinning of the Research Questions.

The literature review had two main foci. One was related to the information and knowledge exchange during supplier involvement in NPD and how supplier involvement affected the work of (Design) Engineers, Purchasers and Sales Engineers. The other focused on the role of social relations in the exchange of information and knowledge.

The literature on supplier involvement in NPD shows a gradual shift in the topics studied: from the quantifiable performance related capabilities to the relational benefits of supplier involvement in NPD. More attention came to be paid to tacit knowledge - based sources of capability and to functional interrelationships. Part of this shift in emphasis involved studies on the changing roles of the individuals working in the functions of (Design) Engineering, Purchasing, and Sales Engineering. The present thesis continues this trend by studying information relationships in the FFE of NPD at the micro-social level of the firm. The aim is to contribute to the development of theory on supplier involvement in new product development (NPD), and to knowledge about the relational benefits of supplier involvement in NPD in particular.

The literature review found that supplier involvement in the FFE of NPD was an under-researched topic. As far as could be established, there has been only one empirical study on supplier involvement in the FFE of NPD (Wagner, 2012). Although the information gathering activities in the FFE of NPD have been the subject of a number of studies (Frishammar, 2005; Frishammer and Ylinenpåå, 2007; Zahay et al. 2004), the benefits of supplier information and knowledge had been overlooked. Interestingly, the extensive worldwide MSU survey of supplier involvement in NPD (Monczka et al., 2000), chose to exclude the 'white box' category of supplier involvement from its survey. As shown in Figure 2.2 , the 'white box' category represents the stage of supplier involvement in which the customer firm first consults with its suppliers about NPD.

The literature on the role of social relations in the exchange of information and knowledge has also undergone a change in focus. Research attention has moved away from the structural view of social ties (i.e., the tie strength and the position of the ties in networks) to the relational view of social ties, that is, to the content of social ties, such as information and knowledge, the exchange of which social ties facilitate. In addition, scholars (Borgatti and Cross, 2003, Hansen, 1999; Rodan and Galunic, 2004) call for more research on the relational aspects of information and knowledge transfer and the role of individuals therein.

In the context of NPD, the research on social ties represents a relatively new field of inquiry. The function of social ties is most evident from the content, intensity and outcome of information relationships that NPD participants engage in.

At the micro-social level of the firm, the outcome of the information relationships between the individuals in the function of (Design) Engineering, Purchasing and Sales Engineering can result in the utilization of supplier information and knowledge in the FFE of NPD.

In order to learn more about the conditions that lead to the utilization of supplier information and knowledge, the present thesis will seek answers to the following Research Questions:

RQ1: What does constitute an information relationship between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of supplier and customer firms during the fuzzy front end (FFE) of new product development (NPD)? What type of information and knowledge is exchanged?

RQ2: How does an information relationship between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of supplier and customer firms work? How does the exchange of information and knowledge take place?

RQ3: Why do some information relationships between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of supplier and customer firms lead to the utilization of supplier information and knowledge, and other do not?

Furthermore, the literature review has resulted in three methodological choices concerning:

- Unit of analysis. The choice of a dyadic information relationship as the unit of analysis is explained in the Conclusion of Part Four, Section 2.4.5;
- Level of analysis. The choice of the micro-social level of the firm as the level of analysis is explained in the Conclusion of Part Three, Section 2.3.4; and
- Theoretical background. The choice of the theory of the Strength of Weak Ties (Granovetter, 1973, 1982) is explained in the Conclusion of Part Four, Section 2.4.5.

More methodological choices made by the researcher concerning the theoretical paradigm, research design and methodology, analysis strategy, as well as the thesis' conceptual framework, are the subject of Chapter 3.

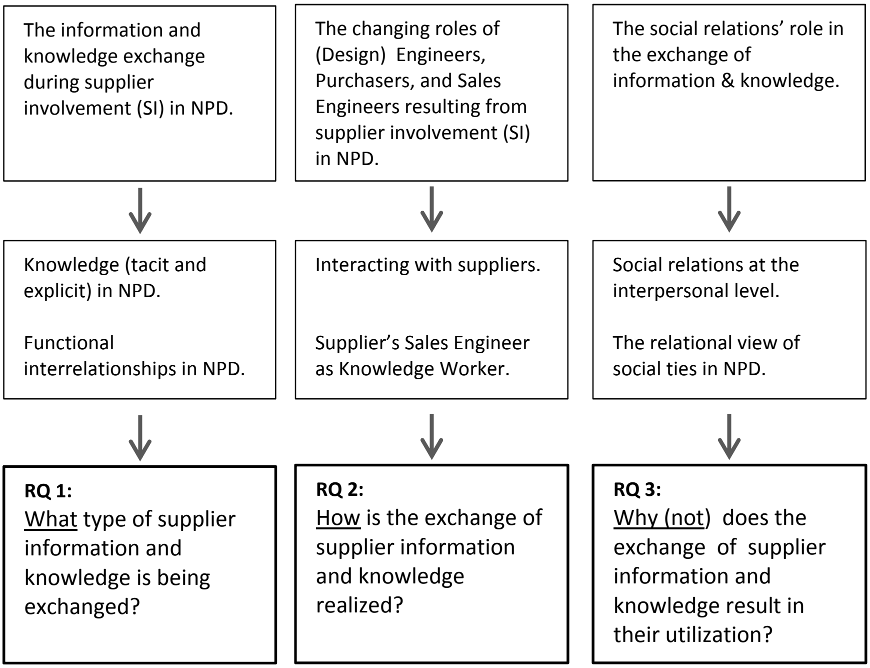

Figure 2.4 Literature underpinning the Research Questions.

Chapter 3: **Research design and methodology**

3. Introduction

The objective of this thesis is to increase our understanding of the utilization of supplier information and knowledge in the fuzzy front end (FFE) of new product development (NPD), and thereby to contribute to the development of theory on supplier involvement in NPD. The literature review in Chapter 2 has established that there is a dearth of research on supplier involvement in the FFE of NPD. The first empirical study addressing the subject was published in the April 2012 issue of Journal of Supply Chain Management by Stephan M. Wagner. The literature review further resulted in the choice of the level of analysis and the unit of analysis.

The choice of the micro-social level (Knorr-Cetina, 1981) of the firm as the level of analysis is justified for two reasons. First, in order to understand the utilization of supplier information and knowledge in the FFE of NPD, we need to learn about the interaction between the individuals who are the main users or providers of that information and knowledge. Secondly, we need to take into account the contexts in which the individuals interact. This methodological choice differentiates the present thesis from most of the studies on supplier involvement in NPD which, as shown in the literature review, had adopted as the level of analysis the firm, or the NPD project.

The choice of the unit of analysis - the information relationship between/among (Design) Engineers, Purchasers, and Sales Engineers of customer and supplier firms - has been informed by the research undertaken by Cross and Sproull (2004) and Borgatti and Cross (2003) who found that the exchange and utilization of information was influenced by the relationship between information seekers and information providers. In view of this, the present thesis conceptualizes the information relationship as a continual, dynamic exchange process involving (Design) Engineers and Purchasers (the information seekers) and Sales Engineers (the information providers).

The FFE of NPD has been described as an ‘opportunity processor’ (Smith and Reinertsen, 1992, 1998) because it is a period of generating and evaluating new product ideas. But Smith and Reinertsen (1992: 47) also warn that:

> *The front-end time is still mostly a vacuum, largely because managers who haven't calculated the dollar value of [product] development delay believe that time is free until people are assigned to it.*

The 'free' time of the FFE is often spent on searching for, and identifying, new information sources, that are both internal and external to the firm. The literature review established that the potential of supplier firms as an external source of information in the FFE of NPD has received little attention. The literature review, outlined in Figure 2.1 (Chapter 2), identified and discussed two streams of literature as relevant to the subject of the present thesis, namely:

- Information and knowledge exchange during supplier involvement in NPD, and the effect of supplier involvement on the work of (Design) Engineers, Purchasers, and Sales Engineers of customer and supplier firms (Part Two, Sections 2.2.1 - 2.2.4 and Part Three, Sections 2.3.1 -2.3.4); and
- The role of social relations in the exchange of information and knowledge (Part Four, Sections 2.4.1 - 2.4.4).

The literature review concluded with the formulation of three Research Questions (Part Five, Section 2.5).

The present chapter is structured as follows. It begins with the identification and justification of the choice of a theoretical paradigm. This is followed by the choices made with regard to the research design and methodology, and the analysis strategy. Next, the chapter presents and discusses the Conceptual Framework (s), followed by sections on Case sampling, Data collection and Data analysis. A special section is devoted to the Coding and Categorizing procedure in order to increase the transparency of data analysis. The chapter concludes with the research quality assessment of the adopted research design.

3.1 Theoretical paradigm

A paradigm is a world view based on assumptions about the world derived from ontology (the philosophy of reality), epistemology (philosophy of knowledge, what we know about the reality and how we come to know it), and methodology (methods and techniques with which to study the reality and increase our knowledge about it). For the researcher, the choice of the theoretical paradigm implies the identification of the underlying assumptions that will guide the research. The literature discerns four categories of theoretical paradigms, based on four different world views: Positivism, Realism (or Postpositivism), Critical theory, and Constructivism (Guba and Lincoln, 2000; Healy and Perry, 2000). Each paradigm has its own ontology, epistemology and methodology bases.

The present thesis has adopted the theoretical paradigm of Critical Realism (Bhaskar, 1998; Easton, 2010, Healy and Perry, 2000; Sayer, 2000), one of several variants of Realism (Harre, 1986).

The following paragraphs cannot do justice to giving a complete picture of the philosophy of Critical Realism. Accordingly, what here follows is a brief outline of the underlying considerations in choosing the paradigm, as they relate to the subject of the present thesis. The choice of Critical Realism has been based on four considerations.

- First, the paradigm of Critical Realism is appropriate for theory building research because it is practitioner-oriented and frequently deploys an inductive mode of inquiry, such as case studies, to build up a new understanding of experiences (Riege, 2003).
- Secondly, a tenet of Critical Realism pertaining to the analysis of causation is relevant to the thesis' Research Question 3, namely: "Why do some information relationships between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of supplier and customer firms lead to the utilization of supplier information and knowledge, and other do not? "
- The critical realist view of causation is shown **in Figure 3.1. Critical** Realism seeks to provide explanations for the events that occurred by identifying the mechanisms that caused the events to occur (Easton, 2010). The literature review in Chapter 2 revealed that, in the context of the present thesis, the causal mechanisms that could help explain the exchange and, ultimately, the utilization of information and knowledge in the FFE of NPD were the social ties when they acted as conduits for the information seeker and provider.

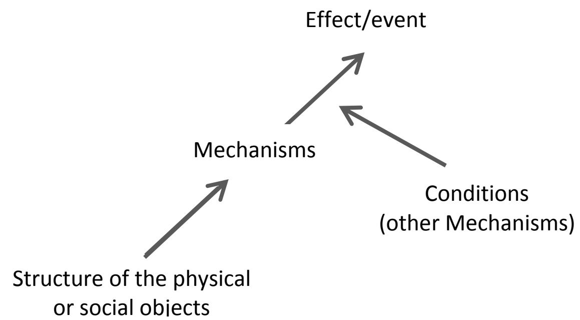

Figure 3.1 The critical realist view of causation (Sayer, 2000: 15).

In the critical realist view, events (e.g., the utilization of supplier information and knowledge) arise from the workings of mechanisms, which derive from the structure of physical or social objects (e.g., the information relationships between the individuals in the FFE of NPD). Events are not pre-determined but contingent on conditions (Sayer, 2000). Thus, events cannot be predicted but can be inferred from the evidence.

In the context of the present thesis, the Condition (or the other mechanism in Figure. 3.1) that could affect the event of the utilization of supplier information and knowledge would, for example, be the move of a supplier production site to another country, thus making the supplier information and knowledge less accessible (i.e., upsetting the established social ties for information exchange).

- Thirdly, the critical realist belief that a single external reality exists independently of our awareness is particularly well suited for the situations involving the seeking and exchanging of information and knowledge (i.e., what type of information is needed or missing?). The critical realists hold that the external reality is difficult to apprehend but can be approximated through multiple perceptions of people who are part of that reality (Easton, 2010; Healy and Perry, 2000). In the present thesis, the multiple perceptions represent the views and experiences of the individuals working in the functions of (Design) Engineering, Purchasing, and Sales Engineering.
- Fourthly, the stratified ontological view of Critical Realism, which recognizes experience as a special domain of reality, justifies the approach taken in the present thesis to use interviews as the prime mode of data collection. Critical Realism holds that there is one 'real' world, but that does not mean that the researcher has an immediate access to it, or can observe all its facets (Zachariadis et al., 2010). In Critical Realism, the external world consists of three overlapping domains (strata) of reality (shown in Table 3.1), namely: the Real (structure of physical or social objects and mechanisms with powers that may or may not bring about change), the Actual (events/changes that occur when the powers of the Real are activated), and the Empirical (our experience of the Real and/or the Actual that we can observe and record). Sayer (2000:12) points out that the stratified ontology of Critical Realism implies:

[…]the recognition of the possibility that powers may exists unexercised, and hence what has happened or been known to have happened does not exhaust what could happen or have happened.

The implication of the stratified ontology of Critical Realism for the utilization of supplier information and knowledge in the FFE of NPD is that the utilization can happen but it is not predetermined, or that it can happen differently than hitherto.

Thus, when the Research Questions of the present thesis are viewed from the ontology of Critical Realism, the Research Questions concern a real world setting, consisting of the social objects of (Design) Engineers, Purchasers, and Sales Engineers.

The structure and powers of the social objects relate to the necessary and contingent relationships that the objects have with one another (Easton, 2010; Sayer, 2000). In the present thesis, the necessary relationships of the social objects follow from their functions. For example, the routine information exchange between Purchasers and Sales Engineers represents a necessary information relationship. By comparison, the contingent relationships pertain to relationships that are not necessary but not impossible. In other words, the relationships may or may not happen. The exchange of information and knowledge between Sales Engineers and (Design) Engineers is an example of a contingent information relationship. The key event in the Research Questions is the utilization of supplier information and knowledge. The focus of the Research Questions is to explain and understand what causes or hinders the utilization of supplier information and knowledge to take place.

On the other hand, when the Research Questions are viewed from the epistemology of Critical Realism, the Research Questions indicate what the researcher wants to learn about the real world setting: the What's, the How's, and the Why's/Why not's of the 'reality' in which the three social objects function. The multiple perceptions that (Design) Engineers, Purchasers, and Sales Engineers hold about the single reality provide a "window on to the reality beyond those perceptions" (Healy and Perry, 2000: 120), thereby helping the researcher to discover and learn about the causal mechanism, that led to the key event to take place (Easton, 2010, Sayer, 2000). Table 3.1 shows the three domains of Reality in the context of the present thesis (shown in italics). For the Critical Realists, the Structures and Mechanisms are real and distinct from the patterns of Events that they generate. In their turn, the Events are real and distinct from the Experiences in which they are apprehended (Bhaskar and Lawson, 1998).

Table 3.1 Stratified ontology of Critical Realism (Bhaskar, 1998: 41)

	Domain of Real	Domain of Actual	Domain of Empirical
Structures and Mechanisms *Dyadic information relations and the intervening mechanism of social ties*	✓		
Events *Utilization of supplier information and knowledge in the FFE of NPD*	✓	✓	
Experiences *Interviews with (Design) Engineers, Purchasers, Sales Engineers and observations of the Researcher*	✓	✓	✓

The ontology and epistemology are two of the three elements of a theoretical paradigm. The third element is methodology, the research method that the researcher chooses for the investigation.

3.2 **Research design and methodology**

The present thesis has adopted a qualitative research methodology because all three Research Questions stem from a social real world context (Robson, 2002). A further choice involved the adoption of a multiple case study approach. Thomas (2011: 4) underlines the benefits of the multifaceted character of case studies:

> *[…] by looking at our subject from many and varied angles, we can get closer to the 'why' and the 'how' […]. A more rounded, richer and more balanced picture of our subject is developed.*

Dul and Hak (2008:4) make a similar point when they note that an often overlooked methodological characteristic of a case study is the fact that a case study is an inquiry of only one single instance, or sometimes a small number of instances, of the object of the study. It is this fact that gives case studies their richness and depth of detail.Easton (2010: 128) argues that Critical Realism and case research are ideally matched because Critical Realism provides ontological and epistemological justifications for case research:

> *Critical realism first of all makes the ontological assumption that there is a reality but that it is usually difficult to apprehend. It distinguishes between the real world, the actual events that are created by the real world and the empirical events of the real world that we can actually capture and record. Thus we will always be surmising about the nature of the real.[…]. Research proceeds by capturing data with respect to ongoing and past events asking at all times why they happened or are happening and taking into account the problems and issues associated with interpreting the empirical data back to the real entities and their actions. The research process is one of continuous cycles of research and reflection [the epistemological assumption]. The final result is the identification of one or more mechanisms that can be regarded as having caused the events.*

Johnston et al. (1999:203), suggests that the case study approach is justified in research situations when:

> *No attempt is made to isolate the phenomenon from its context, but instead, the phenomenon is of interest precisely because of its relation to its context.*

In a similar vein, Dubois and Araujo (2004) contend that case research is particularly appropriate for instances in which the boundary between the phenomenon and its context is unclear and fuzzy, and in which the units of analysis are relationships and interactions. The observations of Johnston et al. (1999) and Dubois and Araujo (2004) are both applicable to the subject of the present thesis. In order to understand the phenomenon of the utilization of supplier information and knowledge in the FFE of NPD, the utilization needs to be studied in the context of the underlying information relationships (the unit of analysis) between/among the parties involved.

Another element affecting the choice of the case study approach is what Maxwell (2005:37) calls the 'experiential knowledge' of the researcher.[2]

3.3 Analysis strategy

The analysis strategy (Yin, 2003) draws on the Conceptual Framework and the Research Questions to guide and maintain the focus of the analysis. In the present thesis, the analysis strategy consists of two rounds of data analysis and a Cross-case Analysis (Chapter 8).

The first round of data analysis pertains to the coding and categorizing of 42 transcripts of interviews, field notes, and meetings. It is described in detail in Sections 3.7.1 - 3.7.5 of this chapter, and in Appendices 3 and 4.

The second round of data analysis is concerned with the Within-case Analyses of the four participating firms (i.e., Firms A, B, C, and D), described in the case reports in Chapters 4-7, and summarized in display matrices (Miles and Huberman, 1994) at the end of the respective chapters. The case reports take the form of narratives and quotations that have been validated by the case study informants. Each Within-case Analysis concludes with several Salient Issues that have been identified in the dyadic information relationships between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of the supplier and customer firms. The Salient Issues pertain to the dyadic information relationships in relation to the utilization of supplier information and knowledge in the FFE of NPD.

The term 'salient' means prominent rather than important. It designates the degree to which an aspect of a dyadic information relationship is uppermost in informants' minds, that is, emerged as such from the interviews with case study informants (after Mellon, 2011). At the same time, it needs to be acknowledged that the selection of Salient Issues is not free of the researcher's bias.

The (very) fact that the researcher has singled out a particular piece of data as a Salient Issue, must be seen as a result of the compound influence of the Conceptual Framework, the Research Questions, and the coding and categorising of the verbatim transcripts. The Salient Issues are supported by the researcher's Reflective Comments and serve as the input for the Cross-case Analysis in Chapter 8.

The analysis strategy uses the technique of 'explanation building' (Yin, 2003).

[2] The choice of a case study approach was also influenced by the affinity of the author and researcher of this thesis with coding, a key method for handling qualitative data in case studies. During her previous employment, the researcher worked as editor of an abstracts journal. In that capacity, she was involved in compiling a thesaurus. The idea of having a thesaurus is that by assigning the thesaurus terms when indexing the content of publications for an abstracts journal (similar to coding transcribed text), the indexing becomes more consistent, and this results in a better searchability of the abstracts journal. The thesaurus terms, or descriptors, are grouped and linked together through the relationships of broader, narrower, or related terms (similar to coding and categorizing). Each term comes with a scope note which describes the intended use of the term (this is similar to code descriptions). However, that's where the similarity with qualitative research ends.

The technique of explanation building, as applied in the present thesis, involves comparing, revising, and iterating the case evidence, captured in Salient Issues and Reflective Comments until a credible explanation of the studied phenomenon (i.e., the utilization of supplier information and knowledge) is reached. The Reflective Comments (placed in separate text boxes and consecutively numbered) represent the researcher's tentative assertions (i.e., summaries and interpretations) about the found case evidence (Stake, 1995).

Table 3.2 shows a hierarchy of the researcher's assertions ranging from assertions made in the form of Reflective Comments about the external information relationships of the firm under study to the Cross-case Assertions about the Multicase Themes. The researcher makes the assertions at four levels of investigation.

The Reflective Comments at the 1st and 2nd level of investigation belong to the Within-case Analyses of the four firms, and can be found in the case reports in Chapters 4-7. The 1st level Reflective Comments conclude Step One of the Within-case Analysis, and concern an introductory observation about the external information relationships of the firm under study. The 1st level Reflective Comment does not identify any Salient Issues because the 1st level Reflective Comments have no direct bearing on the Research Questions and the level of analysis of the present thesis.

Table 3.2 Hierarchy of the researcher's assertions

Assertions	Function	Location
1st level Reflective Comment	An introductory observation	Step One of the Within-case Analyses; Chapters 4-7.
2nd level Reflective Comment	Identifying Salient Issues in the dyadic information relationships captured in the case reports.	Step Two of the Within-case Analyses; Chapters 4-7.
3rd level Reflective Comment	Analysis of Multicase Themes against the background of a major scholarly work. Establishing the credibility of Multicase Themes.)	Stage Two of the Cross-case Analysis; Chapter 8, Section 8.3.
4th level Reflective Comment in the form of Cross-case Assertions	Cross-Case Assertions about the Multicase Themes in relation to the Conceptual Framework. Examining the fit between the evidence captured in the Multicase Themes and the Conceptual Framework.	Stage Four of the Cross-Case Analysis; Chapter 8, Section 8.5.

The 2nd level Reflective Comments are made as part of Step Two of the Within-case Analysis. The Reflective Comments relate to the dyadic information relationships between the individuals working in the functions of (Design) Engineering, Purchasing, and Sales Engineering at the micro-social level of the firm (i.e., the level of analysis of the present thesis). The Reflective Comments identify Salient Issues in the information relationships in relation to the utilization of supplier information and knowledge. The Salient Issues are input for the Cross-case Analysis in Chapter 8. Table 3.3 gives an overview of the number of the Reflective Comments and Salient Issues across the four case reports.

The 3rd and 4th level Reflective Comments belong to the Stage Two and Stage Four of the Cross-case Analysis, respectively, and can be found in Chapter 8.

The 3rd level Reflective Comments concern the analysis of the Multicase Themes at Stage Two of the Cross-case Analysis (Section 8.3). The Multicase Themes emerged from the analysis of Salient Issues that had been earlier identified in the Within-case Analyses. The Multicase Themes are analysed against the background of major scholarly works (analogous to a peer review) in order to establish the Multicase Themes' credibility.

The 4th level Reflective Comments take the form of Cross-case Assertions at Stage Four of the Cross-case Analysis (Section 8.5). The Cross-case Assertions examine the Multicase Themes in relation to the Conceptual Framework. The purpose of the Cross-case Assertions is to examine the fit between the evidence captured in the Multicase-Themes and the Conceptual Framework (Figure 3.3).

A Chain of Evidence (Yin, 2003) is shown in Figure 8.3 in Chapter 8, as part of the Cross-case Analysis.

Table 3.3: Numerical overview of the Reflective Comments and Salient Issues in the case reports

Case report of Firm	Number of Reflective Comments concerning the firm's external information relationships.	Number of Reflective Comments concerning the micro-social information relationships, with identified Salient Issues
A	3	10 Reflective Comments + 10 Salient Issues
B	2	5 Reflective Comments + 6 Salient Issues
C	1	4 Reflective Comments + 4 Salient Issues
D	1	3 Reflective Comments + 3 Salient Issues

(Note: The discrepancy between the number of Reflective Comments and the number of identified Salient Issues in Firm B is due to the fact that the Reflective Comment in Box 5.4 identified two Salient Issues rather than one).

3.4 **Conceptual Frameworks**

A conceptual framework explains in a diagrammatical form what is being studied, sets out the research boundaries, and surmises the relationship (indicated by arrows) between the research dimensions (Marshall and Rossman, 2006; Robson, 2002; Miles and Huberman, 1994). A conceptual framework also serves as a point of reference in the dialogue between the theory found in the literature and the empirical evidence from case study research; it evolves and develops (Eisenhardt, 1989; Dubois and Gadde, 2002).

The evolution of the Conceptual Framework of the present multiple case study design has undergone several iterations, two of which are presented in Figure 3.2 and Figure 3.3. Whereas the (first) Conceptual Framework in Figure 3.2 was informed by a preparatory literature review, the Conceptual Framework in Figure 3.3 is based on the emerging insights from data collection and analysis; it represents the Revised Conceptual Framework.

The objective of both Conceptual Frameworks is to visually describe the aims of the research, which is:

- to study information relationships (the unit of analysis);
- at the micro-social level of the firm (the level of analysis);
- between and among the functions of (Design) Engineering and Purchasing of the customer firm and the function of Sales Engineering of supplier firms (the dimensions of research population);
- in the fuzzy front end of NPD (research boundary); and
- to advance our understanding of the utilization of supplier information and
- knowledge (research focus).

Both Conceptual Frameworks designate social ties as a mechanism through which the information relationship manifests itself, and that enables the utilization of supplier information and knowledge. The frameworks draw on the theoretical concepts of Embeddedness (Granovetter, 1985; Uzzi, 1996, 1997) and the Strength of Weak Ties (Granovetter, 1973, 1982; Hansen, 1999; Levin and Cross, 2004; McEvily and Marcus, 2005; Uzzi, 1996, 1997) which hold that all economic action, such as information search and exchange, is embedded in interpersonal social relationships, and that the structure of social ties (i.e., the tie strength) affects the economic action's result. Both Conceptual Frameworks incorporate three types of social ties (i.e., three kinds of tie modality): strong ties, weak ties, and trusted weak ties, as described in Section 2.4.3 of the literature review in Chapter 2.

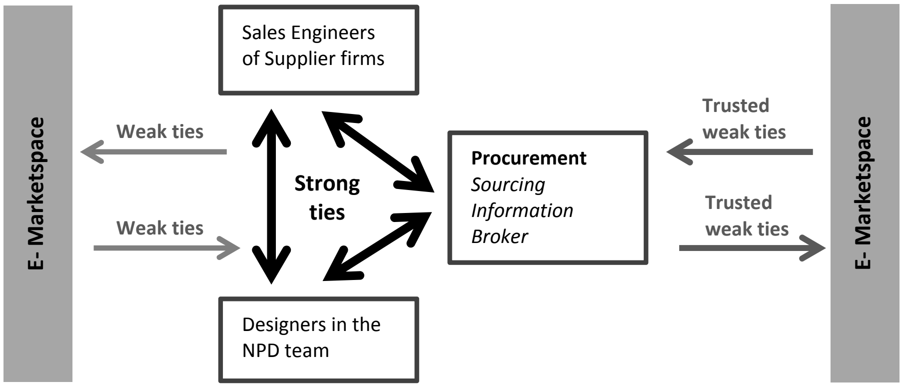

Figure 3.2: (First) Conceptual Framework: Exchange of e-sourcing information in the FFE of NPD.

3.4.1 Conceptual Framework in Figure 3.2

In the (first) Conceptual Framework shown in Figure 3.2, e-sourcing information is conceptualized as information from and about supplier firms that can be accessed through the e-marketspace (digital information about the supply market). The strong ties (positioned at the centre of the framework) represent information relationships within a small group of actors (e.g., parties participating in or contributing to a NPD project, such as the firm's Procurement, Sales Engineers of Suppliers, and the firm's Designers. As described in Chapter 2 (Section 2.4.3), strong ties tend to rely on information which is already available, well tried, and firm-specific (often tacit). Trust among the exchanging parties is a given, the relationship is reciprocal, and leads to learning. Another feature of strong ties is knowledge redundancy (i.e., overlapping knowledge) arising from the internal interaction and sparse external contacts (The Not Invented Here Syndrome is often in evidence). Weak ties (positioned on the left-hand side in Figure 3.2) represent distant infrequent information relationships. An example of a weak tie relationship would be the Designers' occasional contact with suppliers through supplier websites, or incidental searches on the Internet. Thus, the search method deployed by Designers would be that of 'browsing'. A search in browse mode is informal, opportunistic, and data driven (Marchionini, 1995). The information search environment in Figure 3.2 is designated as 'e-marketspace', a digital (electronic) supply market information environment.[3]

[3] The exploratory pilot study, carried out in August 2007 in preparation for the main case study, viewed the websites of three lighting manufacturers as a proxy for the e-marketspace and as a source of supplier information. The study has been reported in a journal article entitled "Supplier Websites: Could They be Inspiring to Lighting Designers?" (Kopecka. Santema, and Hultink, 2010). The pilot's findings were presented at the 15th EIASM conference in Hamburg in July 2008. The reason for the pilot study was twofold. First, to explore the research merit of the supposition that supplier information and knowledge can be valuable to designers at the initial stages of product development; i.e., in the fuzzy front end. The second reason was to get first-hand experience of interviewing, transcribing interviews, and data analysis; i.e., coding, categorizing, and finding common patterns in data.

Information searches performed through weak ties have low search costs. Because of their temporal nature and loose connectivity, weak ties do not assume reciprocity. In addition, weak ties have low knowledge redundancy, low maintenance, and high information diffusion.

Trusted weak ties (positioned on the right-hand side in Figure 3.2) differ from weak ties in that they operate in the environment of benevolence-and-competence based trust, that is, in the environment in which the information seekers and users perceive the information source as trustworthy, competent, and benevolent (Levin and Cross, 2004). As a result of these additional relational characteristics (e.g., trust, benevolence, competency), the information exchange that takes place in the environment of a trusted weak tie relationship can lead to information sharing and learning. In other words, such exchanges bear the characteristics of an information exchange typical of a strong tie relationship.

The Procurement function has frequent contacts with the outside world of suppliers. When searching the e-marketspace, the Procurement department deploys the method of systematic analytical searches, meaning, that the searches are planned, formal and task driven (Marchionini, 1995). As a result, the function of Procurement is in a good position to develop a trusted weak tie relationship with outside information sources, such as supplier firms.

Thus, the supposition behind the Conceptual Framework in Figure 3.2 is that the Procurement function is pivotal to the customer firm's sourcing of information from and about suppliers. The framework further postulates that the exchange takes place electronically (i.e., pertains to e-sourcing information). Lastly, the framework stipulates that the properties of ties (i.e., the tie modality) affect the information relationships both in terms of the what's and the how's of the information exchange (RQ 1and RQ 2), but also in terms of the outcome (i.e., the utilization of supplier information and knowledge), the why/why not's of information relationships (RQ 3).

3.4.2 Revised Conceptual Framework in Figure 3.3

The case study interviews started in November 2009 and ended in December 2010. However, as the data collection and analysis progressed, it also brought to light that some of the assumptions behind the Conceptual Framework in Figure 3.2 did not sufficiently reflect the situation encountered in the participating firms. The revised Conceptual Framework (Figure 3.3) incorporates the emerging insights. The two Conceptual Frameworks differ in three ways.

The first difference concerns the position of the Procurement function. In Figure 3.2, the Procurement function is at the centre of the framework and performs the role of an information broker or boundary spanner, between the firm and the (digital) outside world of supplier firms (i.e., the e-marketspace).

The framework further ascribes to the Procurement function the capability to perform systematic analytical searches in the e-marketspace, whereas the other two parties in the framework, the Designers and suppliers' Sales Engineers only engage in incidental information searches (i.e., deploy the search method of 'browsing'). The interviews with case study informants, however, revealed that the role of information broker was not an exclusive domain of Procurement. Furthermore, the Procurement function in the participating firms was much less prominent in the firm's NPD activities than suggested and described in the literature (Di Benedetto et al., 2003; Lakemond et al., 2001, 2006; Van Echtelt et al., 2008; Wynstra et al., 1999, 2000, 2001, 2003) that had informed the Conceptual Framework in Figure 3.2. As a matter of fact, one of the participating firms did not even have the traditional Procurement function anymore, and used an e-procurement system instead. Lastly, the case study informants proposed changes in the terminology used: they preferred the term Purchasing with which to describe Procurement, and the term (Design) Engineers with which to describe Designers.

The second difference between the Conceptual Frameworks in Figure 3..2 and Figure 3.3 relates to the concepts of 'e-sourcing information' and 'e-marketspace'. The interviews revealed that whereas the information that passed through Purchasing could be described as e-sourcing information (factual and operation-oriented information from and about suppliers, transmitted and stored electronically), the information that was exchanged between the Sales Engineers of supplier firms and the (Design) Engineers of customer firms was problem-oriented, and had much more the character of knowledge exchange in face-to-face meetings. Since the focus of the present thesis is to discover how the information and knowledge of supplier firms can contribute to solving (design) engineering problems in the FFE of NPD, the concepts of'e-sourcing information' and the 'e-marketspace' (represented by supplier websites) were dropped and replaced by the concept of 'supplier information and knowledge'.
Another pointer that the case study informants made concerned the status of supplier firms. The case informants pointed out that, as a rule, the supplier firms that were invited to participate in the customer firm's NPD came from the ranks of the so-called 'preferred' suppliers (i.e., suppliers with a proven record of performance with whom the customer firm had a longstanding relationship). This circumstance makes weak tie relationships with suppliers less likely.

The third difference between the Conceptual Frameworks in Figure 3.2 and Figure 3.3 pertains to the tie configuration. The Conceptual Framework in Figure 3.2 infers that the social ties operating between/among the individuals in the functions of Procurement, Designers in NPD teams, and supplier's Sales Engineers have a strong tie relationship with one another, and form a triadic information relationship. However, the found evidence suggests that it is rare for these three functions to actually hold a meeting together. On the contrary, the case study informants indicated that whereas dyadic contacts were commonplace, triadic contacts happened only rarely.

These new insights from the case evidence resulted in the revised Conceptual Framework shown in Figure 3.3, which presents the information relationships as a set information relationship dyads in which the three functions take turn in participating. The dyadic configurations in the present case study can be both inter-firm and intra-firm. Examples of an inter-firm dyadic configuration would be a dyad CP/SSE representing an information relationship between the customer firm's Purchasers (CP) and the supplier's Sales Engineers (SSE), or a dyad SSE/CDE representing an information relationship between the supplier's Sales Engineers (SSE) and the customer firm's (Design) Engineers (CDE), or a dyad SDE/CDE representing an information relationship between the supplier's (Design) Engineers (SDE) and the customer firm' (Design) Engineers (CDE), or a dyad CP/SDE between the customer firm's Purchasers (CP) and the supplier's (Design) Engineers (SDE). Examples of an intra-firm dyadic configuration would be a dyad representing an information relationship between Purchasers and (Design) Engineers of the customer firm (CP/CDE), or an information relationship between (Design) Engineers and Sales Engineers of the supplier firm (SDE/SSE). The six possible configurations of dyadic information relationships are shown in the Conceptual Framework in Figure 3.3.

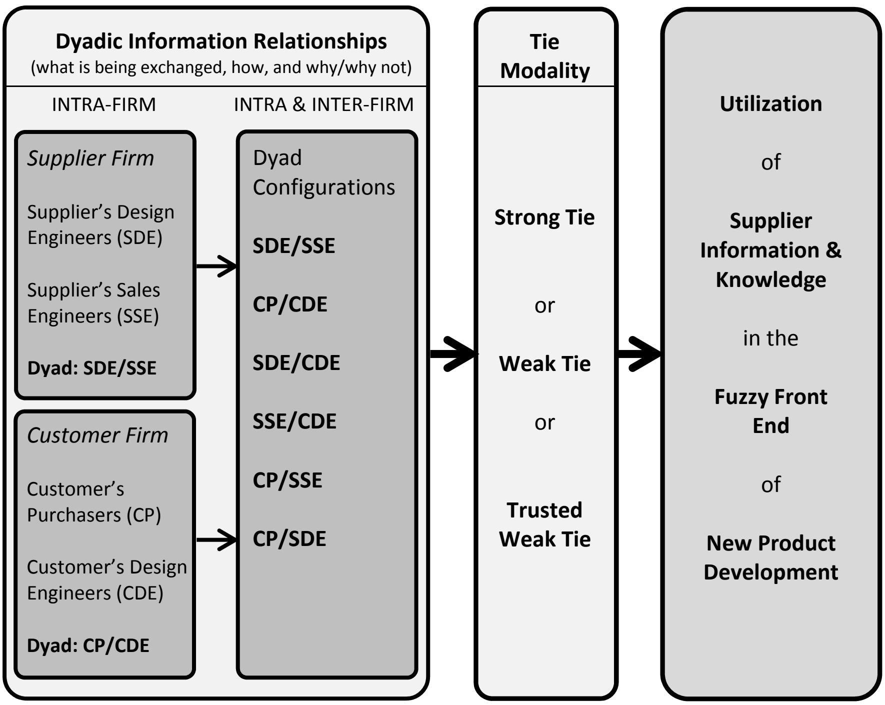

Figure 3.3 Revised Conceptual Framework: Exchange of supplier information and knowledge in the FFE of NPD. (Note: The term 'Sales Engineer' encompasses not only the function of the Sales Engineer as such, but also any other representatives of the supplier firm engaged in the 'selling' of products to the customer firm. For example in Firm B, the supplier firm is represented by the Director Sales & Engineering and in Firm D by the Account Manager).

The supposition behind the Conceptual Framework in Figure 3.3 is that the utilization of supplier information and knowledge in the FFE of NPD is an outcome of a dyadic information relationship between the sender and the recipient, and that this information relationship is enabled by tie modality (i.e., the type of social tie that exists between the exchanging parties). The type of tie (e.g., strong tie, weak tie, or trusted weak tie) that operates within the dyad influences the What, and the How of the exchange of supplier information and knowledge (RQ1 and RQ 2). Ultimately, the type of social tie also influences whether or not the exchanged supplier information and knowledge will be utilized (RQ 3). Interestingly, Gulati, Nohria, and Zaheer (2000: 208) have pointed out that tie modality could be a resource for competitive advantage:

> *It is not difficult to see how certain tie characteristics might not only be valuable but also difficult for competitors to imitate.*

In conclusion, the basic premise behind the Conceptual Frameworks in Figure 3.2 and Figure 3.3 remains unchanged: the social ties function as mechanisms that enable the exchange, and ultimately, the utilization of supplier information and knowledge. What has changed are the framework's elements (dyadic instead of triadic relationships), and some clarifications of terminology: Procurement was replaced by Purchasing, Designers by (Design) Engineers, and the concepts 'e-sourcing information' and 'e-marketspace' were substituted with a joint term of 'supplier information and knowledge' (defined as a core construct in Chapter 2).

3.5 **Case study sampling**

Finding firms for the case study was a difficult and lengthy process. The adopted research design of a multiple case study presupposes participation of several firms. According to Creswell (2006: 128), a study consisting of 4-5 cases should be sufficient to identify themes of the cases, and to conduct a cross-case theme synthesis. Eisenhardt (1989: 545) notes that although there is no ideal number of cases, a number between 4 and 10 cases usually works well. Stake (2006: 22) argues that the benefits of multicase study will be limited if fewer than 4 and more than 10 cases are chosen. The sampling strategy that the present case study followed was one of purposeful sampling and convenience (Patton, 2001). Convenience sampling, or chain sampling strategy (Miles and Huberman, 1994), identified cases of interest through recommendations of the thesis supervisors and colleagues at work. Thereafter, the strategy of purposeful sampling was applied. This means, that the cases were selected because they were information-rich and enabled an in-depth understanding of the information and knowledge exchange between the members of the customer firm's functions of Purchasing and (Design) Engineering, and the supplier's function of Sales Engineers.

Or, as Patton's description of purposeful sampling states (Patton, 2001: 46): "cases from which one can learn a great deal about issues of central importance to the purpose of the research."

After a year and a half and with the help of the thesis supervisors and colleagues at work (i.e., through convenience sampling), four focal firms (N=4) were found from the following manufacturing industries: aerospace, automotive, industrial automation, and aeronautical equipment. Table 3.4 describes the firms by industry category and their supplier tier level.

Table 3.4: Participating firms and the studied inter-firm information relationships

Firms	Industry	Country	Tier level in the supply chain	Inter-firm information relationships
A	aerospace	Netherlands (NL)	tier-one	focal firm/ 6 suppliers
B	automotive	Netherlands (NL)	tier-two	focal firm/ 1 supplier
C	industrial automation	Netherlands (NL) & Germany (DE)	tier-one	focal firm/ 2 customers
D	aeronautical equipment	Netherlands (NL)	tier-one	focal firm/ 1 supplier

The term 'focal firm' is used deliberately in order to make a distinction between the participating firms (i.e., the focal firms), which in the present thesis are all supplier firms, and the focal firm's own suppliers. Making this distinction is necessary because as Table 3.4 shows, the four participating firms represent tier-one and tier-two suppliers, that is, the firms occupy different positions in the supply chain. This fact gives rise to a diversity of customer/supplier relationships.

For example, if a focal firm is a tier-one supplier, it supplies product components directly to the customer (i.e., to an original equipment manufacturer, or OEM). The same tier-one supplier, however, is a customer to its own suppliers. By comparison, if a focal firm is a tier-two supplier, it supplies product components to an OEM's tier-one supplier. In other words, the customer of a tier-two supplier is another supplier. The interactions between firms, particularly when studied from the perspective of information relationships (the unit of analysis in the present thesis) between individuals representing the firms' diverse functional areas, are therefore complex. It is in such situations that the multi-faceted nature of case studies, which allows to study the phenomenon from different angles and through diverse perceptions, is particularly helpful in coming to understand the What's, the How's and the Why's/Why not's of dyadic information relationships.

The product development projects at the four focal firms were selected in cooperation with the firms' representatives. Initially, the case study informants came from Purchasing & Purchasing Management, and from Engineering & Engineering Project Management. Later, the snowballing sampling technique was applied in order to recruit more informants, particularly from among the suppliers and customers of the four focal firms.

3.6 **Data collection**

The data collection started with a general presentation of the research objectives by the researcher at each of the four participating firms. Profiles of the four focal firms (A, B, C and D) are in Appendix 5. The actual data collection proceeded in three phases.

Phase 1 of data collection

In the first phase of data collection, members of (Design) Engineering and Purchasing in the four focal firms received an Executive Summary of the case study objective (Appendix 1) and a questionnaire (Appendix 2) with twenty-two questions, both open-ended and closed. Prior to sending the questionnaire to the case study informants, the questionnaire's content was consulted with one of the thesis supervisors and a Purchasing Manager in one of the participating firms. Here it is important to emphasize that the objective of the questionnaire was not to collect data, but to find leads, and to sensitize the case study participants to the research subject.

The questionnaire asked the informants to name at least five of their information sources, and at least five personal contacts, and to classify them using one of the nine generic information seeking situations (Cross and Sproull, 2004; Millar et al., 1997) by answering the following questions: "To whom would you turn for advice if you were to find yourself in one of the following situations?"

- Looking for information on facts (the 'know-what' information seeking situation);
- Looking for information about a process (the 'know-how' information seeking situation);
- Looking for a person who could help (the 'know-who' information seeking situation);
- Looking for a reason (the 'know-why' information seeking situation);
- Looking for a scenario (the 'know-what if' information seeking situation);
- Looking for a background (the 'know-what was' information seeking situation);
- Looking for a problem definition (the 'know dimensions' of information seeking situations);
- Looking for a verification (the 'know if I am on the right track?' information seeking situation); and

- Looking for a justification (the 'know precedents' information seeking situations).

Another set of questions addressed the informants' perception regarding the usefulness of supplier information applying the nine criteria of information quality, namely: accuracy, relevance, completeness, timeliness, diversity, accessibility, comprehensibility, content personalization, and dynamic content (DeLone and McLean, 2004). The questions, drawn from the literature on information seeking behaviour, had as objective to steer the informants' answers in the direction of the Research Questions.

Since the focus of the study is the utilization of supplier information and knowledge by customer firms, the questionnaire was sent out only to focal firms that fulfilled the role of a customer (i.e., to firms A, B and D). In total, 20 questionnaires were sent out to (Design) Engineers and Purchasers. Of the 20 questionnaires, 5 were not returned due to the informants' lack of time. Among the returned questionnaires, some questionnaires were incompletely filled in. It became evident that the informants were not used to analyse their information searches in any great detail. It was only during the follow-up interviews that patterns in the informants' information seeking behaviour began to emerge. The questionnaire resulted in several leads to new informants both within and outside the focal firms.

Phase 2 of data collection

The second phase of data collection consisted of 20 semi-structured interviews with the questionnaire recipients. The interviews were conducted in English or in Dutch. One interview was done over the phone, and one interview was a group interview (at the request of the informants) involving three people. The remaining interviews were done in person. The interviews lasted 60-90 minutes.

The chief objective of the interviews was to gain insights into the informant's information seeking behaviour in terms of the behavioural/structural properties (e.g., information exchange habits and routines), and the behavioural/relational properties (e.g., trust, reciprocity in information exchange, and the informant's awareness of information needs and capabilities of the people with whom the informant exchanged information).

Phase 3 of data collection

The third phase of data collection focused on the interviews with informants from supplier firms, that is, on the informants from Firm C and its two customer firms (nine informants) and eight informants from the supplier firms that had as their customers firms A, B and D.

In this phase of data collection, the informants were approached by an e-mail explaining the purpose of the research (with an Executive Summary attached), mentioning the name of the focal firm's informant as a reference. The informants were not given a questionnaire to complete. Instead, the interview (lasting 60-90 minutes) used an interview schedule of issues (Thomas, 2011) which drew heavily on the list of topics that emerged from the previously held interviews.

In summary, Table 3.5 presents a numerical representation of the total of informants interviewed per functional area: (Design) Engineering (21), Purchasing (6), and Sales Engineering (12). Table 3.5 also reveals the uneven representation of the three functions. For example, in firm C, the function of Purchasing is missing altogether, because it has been replaced by an e-procurement system, thereby making Purchasing a back-office function. Fortunately, the information relationship studied in this particular firm concerned the relationship between the focal firm (as supplier) and its two customers, and therefore the absence of the Purchasing function did not affect the research design.

Table 3.5: Total numerical representation of the functions (Design) Engineering, Purchasing, and suppliers' Sales Engineers/Management taking part in the case study.

Firm	Engineering & Project Management	Purchasing & Purchasing Management	Supplier Sales Engineers & Sales Management	Total
A	8	1	6	15
B	7	1	1	9
C	5	-	4	9
D	1	4	1	6
Total	21	6	12	39

In all, 37 interviews with 39 informants (There was one group interview involving three people) were conducted in English or in Dutch. According to Griffin and Hauser (1993), interviewing individually 20-30 case study participants is considered sufficient to ensure a representative view of a researched subject.

The interviews were taped, transcribed, and sent to the interviewees for validation. Next, using the computer software programme Altlas-ti 6.2, the interview transcripts were coded and categorized. To increase research reliability**,** the process of coding and categorizing included writing of analytic memos. The software programme Atlas-ti (Friese, 2011) enables to record the research progress through keeping several types of analytic memos. The researcher made use of code memos (registering the changes in codes), code scope notes (descriptions of codes), and comments (brief notes that can be written across the segmented text). In addition to the 37 interviews, there were 5 transcripts covering observational data such as field notes, and Minutes of Meetings. The documentation about focal firms and their projects, and e-mail correspondence with case study informants completed the triangulation of data collection (Yin, 2003).

3.7 **Data analysis**

Wolcott (1994: 1-54) describes data analysis as a process of transforming qualitative data into intelligible accounts. In Wolcott's view, the transforming process consists of three interconnected phases: description, analysis, and interpretation (DAI).

- Description addresses the question: 'What is going on here?' Data consist of observations made by the researcher and/or reported to the researchers by others;
- Analysis addresses the identification of essential features and the systematic description of interrelationships among them – "How things work or don't work, and how they might be made to work 'better';
- Interpretation addresses processual questions of meanings and contexts: "What does it all mean? What is to be made of it all?

In the present thesis, the process of transforming the qualitative data extends over seven chapters, of which four chapters can be described as descriptive/analytic, and three chapters can be described as analytic/interpretative.

The four Within-case Analyses (Chapters 4-7) give a descriptive/analytic account of the dyadic relationships found operating in each of the four firms, and identify the Salient Issues in these relationships. The Salient Issues serve as input for an analytic/interpretative Cross-case Analysis in Chapter 8. Chapter 9 presents an interpretative discussion of the thesis' findings. Lastly, the sections 3.7.1 – 3.7.5 of the present chapter focus on the analytic/ interpretative process of coding and categorization of the interview data.

The data analysis in the present thesis relies both on deduction and induction. The deduction is guided by the three Research Questions based on the identified gaps in the literature, and the revised Conceptual Framework (**Figure 3.3**). The framework outlines the research population as consisting of (Design) Engineers, Purchasers, and Sales Engineers and forming six possible dyad configurations of information relationship, namely:

- Supplier's Design Engineers/Supplier's Sales Engineers (SDE/SSE)
- Customer's Purchasing/ Customer's Design Engineers/ (CP/CDE)
- Supplier's Design Engineers /Customer's Design Engineers (SDE/CDE)
- Supplier's Sales Engineers/ Customer's Design Engineers (SSE/CDE)
- Customer's Purchasing/ Supplier's Design Engineers (CP/ SDE)
- Customer's Purchasing/ Supplier's Sales Engineers (CP/ SSE)

The Conceptual Framework further conjectures that it is tie modality that enables the dyadic information relationships and their outcome, the utilization of supplier information and knowledge (research focus) in the FFE of NPD (research boundary) to take place.

The induction is based on the interpretation of the words of the case study informants (i.e., the raw data). Paraphrasing Strauss and Corbin (1998: 132): the focus of the data analysis is to identify the information and knowledge exchange situations (what is being exchanged, how, and why), and to find patterns in them, so as to better understand the conditions leading up to the exchange, the interaction between and among the found dyads, and the consequences of the exchange (in the present thesis: the utilization, or non-utilization, of supplier information and knowledge in the FFE of NPD).

The Reflective Comments made by the researcher throughout the four Within-case Analyses (Chapters 4-7) and the Cross-case Analysis (Chapter 8) are inductive because they interpret the emerging patterns and themes and relate them to the extant perspectives and theories from the literature.

3.7.1 Coding and Categorizing

The activity of coding is the first step in data analysis. Miles and Huberman (1994: 56) describe the coding activity as follows:

> *To review a set of field notes, transcribed or synthesized and to dissect them meaningfully, while keeping the relations between the parts intact, is the stuff of analysis. This part of analysis involves how you differentiate and combine the data you have retrieved and the reflection you make about this information.*

Saldaña (2009) and Frieze (2011) remind us that coding is a cyclical process, and they make a distinction between the First Cycle and the Second Cycle of coding methods. Strauss and Corbin (1998) define three phases in coding, namely: ‘

- open coding (Appendix 3);
- axial coding (Appendix 3); and
- selective coding (Appendix 4).

Of the three methods, ‘open coding’ takes place in the First Cycle coding, whereas ‘Axial Coding’ and ‘Selective Coding’ belong to the Second Cycle of coding (to be described in Sections 3.7.4 and 3.7.5 and in Appendices 3 and 4, respectively).

The coded data in the present thesis consist of interview transcripts, participant observation field notes, Minutes of Meetings, and firms’ documentation. The length of coded segments varies from 1-3 sentences to text paragraphs. In total, 42 documents have been coded of which 37 are interview transcripts that range in length from 13 to 24 pages (some 600 pages in total).

3.7.2 Codes

According to Saldaña (2009: 3) a code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data.

Miles and Huberman (1994: 56) see codes as "labels for assigning units of meaning to the descriptive or inferential information compiled during a study". Codes are usually attached to "chunks' of varying size: words, sentences, or whole paragraphs, connected or unconnected to a specific setting. They can take the form of a straightforward category label, or a more complex one (e.g., a metaphor). An example of a metaphor code in the data of this case study would be the code *"troubleshooting"* (describing an act of mutual assistance, for example, of a tier-one supplier and a tier-two supplier who both try to solve the problem of a defective product component encountered by a customer of the tier-one supplier). An example of a straightforward (i.e., descriptive) code/category label would be *'drawings', 'trade show',* or *'manufacturing plant'.*

Code Types

Developing the codes belongs to the First Cycle of coding. A complete list of codes is provided in Appendix 3, and can be divided into five types (after Saldaña, 2002):

1/ Descriptive codes (Describe the topic of the coded segment). Descriptive codes are usually nouns such as the above example of *'drawings'.* There is no interpretation involved.

2/ Structural codes (Are content-inferred, or conceptual codes). The codes can be phrases that relate the coded data segment to a specific research question. Here one has to bear in mind that the Research Questions (together with the Conceptual Framework) influence the way in which the researcher had conducted the interview, so that the structural codes assigned to the transcripts of interviews are not free from researcher bias. This fact notwithstanding, the structural codes form the basis for categorization because they identify large segments on broad topics (Saldaña (2009: 68). Therefore, structural codes lend themselves for creating sub-categories through which categories acquire greater explanatory power (after Strauss and Corbin, 1998: 124). In the data of this case study, the code *'relationship initiative'* would be an example of a structural code. In the Second Cycle of coding, the code *"relationship initiative"* was broken down into sub-categories in order to further specify the parties behind the initiative. For example, *Relationship: initiative/customer; Relationship: initiative/engineering, focal firm; Relationship: initiative/suppliers.*

3/ In-vivo codes (code 'Quotations') allow to hear the informants' voice. Often in-vivo codes capture the sentiment of the informants better than any code could. The following example illustrates the powerful effect of in-vivo codes. A holder of several patents and a director of a successful engineering firm says during the interview: *It's very important not to assume that the product is finished and there is nothing more to improve. Improving the product means that you keep the product alive.* One could assign this segment a code such as *'R&D supplier, incremental'*, which the code scope note describes as 'supplier's incremental innovation projects', together with a property/dimension code (discussed below), such as *'Drivers PD (product development), technology-driven'.*

However, in this situation the codes feel less adequate because they fail to capture the personal conviction of the informant which this segment conveys, and which is worth highlighting given the informant's history in patent-acquiring record. (Incidentally, the code list does contain a code *'patents'* as well).

4/ Process codes (Describe an observable human activity). The codes are in the form of gerunds (the Wesbter online dictionary defines the 'gerund' as the -ing form of a verb when used to form a noun phrase, e.g., the verb learning in the sentence "Learning English is an easy process for some"). In the data of the present thesis, the code *'knowledge sharing'* would be an example of a process code. Strauss and Corbin (1998: 163-179) underline the importance of discovering the action/interaction aspects behind the processes. Thus, the code of *'knowledge sharing (KNWLS)'* in Appendix 3 has been sub-divided into twelve sub-categories. This recoding process resulted in a clearer picture of what is going on in the data about *'knowledge sharing'*. For example, '*who*' is involved (e.g., customer firm, focal firm, supplier firm), and *'where'* (e.g., meetings), and '*how*' does the knowledge sharing take place. (e.g., tests, information dissemination).

5/ Property/dimension codes (Are general or specific properties or dimensions of categories). The codes denote the location of a property or a dimension along a continuum (Strauss and Corbin, 1998). Thus, the property/dimension codes can be attached to/combined with any other code in order to make the meaning of the first code deeper. In the data of the present case study, the examples of property/ dimension codes would be the codes *'frequency'*, *'location distance'*, *'positive opinion'*, '*negative opinion'*, and such like. (An example of how property/dimension codes work will be given in the Section *Examples axial coding* later).

Assigning Codes

A coded segment can be assigned more than one code. This is called simultaneous coding (Saldaña, 2009:6). The reliability (dependability) of codes is achieved by keeping a code list with descriptions for each code. A code description, in the form of a scope note, is not a definition. Rather, it describes the most frequently occurring context in which the code is applied. The consistency in coding is further improved by writing analytical memos so as to keep track of changes in the codes. The Computer Aided Qualitative Data Analysis (CAQDAS) tools, such as Atlas-ti, used in the present thesis, frequently have code memoing features. Another useful feature of Atlas-ti is the possibility to create 'families'; i.e., to group the segmented data pertaining to one research dimension, e.g. (Design) Engineering together (i.e., cutting across all participating firms), and thus limit the data analysis to that one family only.

3.7.3 Open Coding

Open coding belongs to the First Cycle of coding, during which the text is broken down into meaningful segments. The segments are compared for similarities and differences, and have first tentative codes assigned to them.

In this stage, the need to recode; i.e., to find a more precise code is more the rule than an exception. In the present case study, the process of 'open coding' has been gone through three times.

The first time involved a software try-out: learning to work with the CAQDAS tool Atlas-ti, by coding five transcripts. The second time of open coding was during a two day Atlas-ti course for which one case study (consisting of seven transcripts) was coded as an exercise, and subsequently recoded. Some codes were found to be too broad and needed to be defined more narrowly. An example of recoding would be the code *'relationship mentality'* which was changed to *'relationship initiative'*. The third and final round of open coding covered all the interview transcripts (37 in all) and 5 transcripts of observational data, such as Minutes of meetings, and field notes.

At the end of the First Cycle of coding, the total number of codes was 177 (Appendix 3).

3.7.4 Axial Coding

Axial coding involves clustering and breaking down of codes into larger or smaller units; i.e., creating categories and sub-categories. Strauss and Corbin (1998: 124) describe the process of axial coding as follows:

> *By coding intensively and concertedly around single categories, the analyst begins to build up a dense texture of relationships around the "axis" of the category being focused on.*

The axial coding resulted in the creation of 44 categories and 118 subcategories (Appendix 3). The recoding process is iterative and stops when the researcher is satisfied with the result, but the possibility that the recoding could be improved is always present. It is important to remember that in the phase of 'axial coding' the focus of analysis shifts away from codes to code categories.

The code categories aim to capture the repeated patterns of conditions (a set of events), actions/interactions, and their consequences, as reflected in the data. Thus, by regrouping, building up, and fracturing the categories, the researcher obtains a fine-grained perspective on the data.

Examples Axial Coding

Shown below are two examples of how axial coding can help achieve a finer-grained perspective:

- The phenomenon 'information relationship' can be said to be present at three organizational levels of the firm. This led to the creation of the following three categories:
  1/ the category code *REL- relationship-firm level* (pertains to information-related activities that the informants mentioned and that took place at the level of focal firm, supplier firms, or customer firms);

2/ the category code *RELGL- relationship-group level* (pertains to information-related activities of functional groups such as (Design) Engineers, Purchasers, and Supplier's Sales Engineers from which our informants were recruited); and

3/ the category code *KNWLS-knowledge sharing* pertains to the individual level involving staff members of (Design) Engineering, Purchasing and Supplier's Sales Engineering.

However, the present case study is only interested in the categories RELGL and KNWLS, the latter two organizational levels. But in order to get an 'undiluted' perspective on the data found at these two levels, it is necessary to create categories for all three levels, so as to be able to exclude a category level when needed. In this particular example, the category to be excluded is the category of REL-relationship-firm level.

The term 'undiluted' is used purposefully. By and large, the case study informants did not participate in activities at the firm level (e.g., CEO meetings), but they mentioned the outcomes of such meetings in the interviews. Compared to data acquired from the group level (RELG) category and individual level (KNWLS) category, which produced data that directly reflected the informants' own work practices and experience, the data from the firm level category (REL) represent only secondary source data. The question then is: should one code the secondary data, or should one ignore them? Coding the segments in full, irrespective whether the coded segments contained primary or secondary data, but creating specific organization level categories (REL), so that the narrowing down of the focus of analysis (i.e., excluding a category when needed) remained an option and a good alternative.

- Another way of gaining a finer-grained perspective on data is by creating property/dimension codes (Strauss and Corbin, 1998; Frieze, 2011). These codes refer to properties or dimensions which, when applied to a specific category, give the category an extra depth of meaning. The advantage of property/dimension codes is that they make the code lists less cluttered.

  An example of a dimension code in the data of this thesis is the code *Opinion*, with its subcategories: *Positive*, *Negativ*e. Suppose that a coded segment contains a negative remark about 'preferred suppliers'. In addition to the code '*preferred suppliers'*, there would have to be another code '*preferred suppliers-negative'*. An alternative is to create the code Opinion, with sub-categories Positive, Negative. Thus, the selected segment gets two codes, the code *'preferred suppliers'* and the code *'Opinion, negative'*. An additional advantage of this type of coding is that now a compilation can be made of the informants' positive as well as negative opinions, irrespective of the coded segments to which they have been assigned. Thus, the property/dimension codes help obtain new perspective on the data.

At the end of axial coding, the data were grouped in 44 categories. In reducing 177 codes to 44 code categories (written in block letters in Appendix 3), the first consideration was that the code categories helped to answer the Research Questions. The second consideration was that the code categories represented the dimensions of research population; i.e., (Design) Engineering, Purchasing, and Supplier's Sales Engineers, and their information relationships (the unit of analysis). Listed below are some examples of codes and how they relate to Research Questions.

RQ 1: *What does constitute an information relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of supplier and customer firms during the fuzzy front end (FFE) of new product development (NPD)? What type of information and knowledge is exchanged?*

The following code categories apply: Drawings, Engineers Information (4 sub-categories), Knowledge Sharing (12 sub-categories), Manufacturing processes (9 sub-categories), Manufacturing tools and tooling (3 sub-categories), Patents, Prototypes, R&D (customer firm, focal firm, supplier firm: 16 sub-categories), Standards (2 sub-categories), Supplier Product Parts (5 sub-categories), Trade Shows, and Trust (9 sub-categories).

RQ 2*: How does an information relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of supplier and customer firms work? How does the exchange of information and knowledge take place?*

The following code categories apply: Communication channels, Internet, Matrix organization (2 sub-categories), Personnel changes, Outsourcing, Quality Certification (3 sub-categories), Preferred Suppliers (2 sub-categories), R&D meetings; Relationships (group level: 13 sub-categories); Relationships (inter-firm:7 sub-categories), Relationship initiative (3 sub-categories), Relationship ties (4 sub-categories); Risk management, Sourcing Committee, Supplier Audits, Supplier Development, Supplier Integration (2 sub-categories), Supplier price policy, Supplier segmentation strategy, Supplier selection (5 sub-categories), Supplier participation strategy, Supplier' Sales Engineers (6 sub-categories), Teams (3 sub-categories), Trade Shows, Triads (6 sub-categories), and Trust (9 sub-categories).

RQ 3: *Why do some information relationships between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of supplier and customer firms lead to the utilization of supplier information and knowledge, and other do not?*

The following code categories apply: Culture, Competition (2 sub-categories), Management decision making, Matrix organization (2 sub-categories), Relationships (inter-firm: 7 sub-categories), Relationships (group level: 13 sub-categories), Relationship initiative (3 sub-categories), Relationship History, Relationship ties (4 sub-categories), Supplier selection (5 sub-categories), Triads (6 sub-categories), and Trust (9 sub-categories).

3.7.5 Selective coding

Selective coding is the process of integrating and refining categories in order to choose two or more Central Categories, or themes. In the words of Strauss and Corbin (1998: 146):

> *A central category has analytic power. What gives it that power is its ability to pull the other categories together to form an explanatory whole. Also, a central category should be able to account for considerable variation within categories.*

The results of the selective coding are presented in Appendix 4. The process of selective coding has been done in two phases.

Phase 1 of selective coding

In the first phase of selective coding, the 44 axial code categories were reduced to seven Core Categories. Appendix 4 presents each Core Category in a five column table. The first column contains the axial code categories from which the new Core Category originates. The second column introduces the name of the Core Category. The third column provides a scope note of the Core Category. The fourth column lists key literature pertaining to the research issues that relate to the Core Category. Finally, the fifth column provides an indication of what the Core Categories mean in terms of the present thesis' practical and theoretical contribution.

The creation of Core Categories was guided by the Research Questions and how they link up to the original data. Listed below are the Core Categories with the related Research Questions given in brackets.

- Core Category 1: Information transfer facilitators (RQ1; RQ2)
- Core Category 2: Supplier capabilities (RQ 1; RQ 3)
- Core Category 3: Knowledge creation, intra-firm group level (RQ3)
- Core Category 4: Information relationships, intra-firm group level (RQ 2)
- Core Category 5: Knowledge creation, inter-firm group level (RQ3)
- Core Category 6: Information relationships, inter-firm group level (RQ2)
- Core Category 7: Trust (RQ1; RQ2; RQ 3)

An explanation of the Core Category's relation to the Research Questions reads as follows:

- The Information transfer facilitators, Supplier capabilities, and Trust explain what is being exchanged. Thus, Core Capabilities 1, 2 and 7 address RQ1.
- The Information transfer facilitators, the Information relationships of the individuals/groups (the micro-social level of analysis) working both within (intra) the firm and between (inter) the firms, and Trust explain how the exchange of supplier information and knowledge takes place. Thus, Core Categories 1, 4, 6 and 7 address RQ2;

- Supplier capabilities and Knowledge creation resulting from the exchange of information between the individuals/groups working both within (intra) the firm and between (inter) the firms, and Trust explain whether or not supplier information and knowledge are utilized.
- Thus, Core Categories 2, 3, 5 and 7 address RQ3.

Phase 2 of selective coding

In the second phase of selective coding, the seven core categories have been further subsumed into four Central Categories. Strauss and Corbin (1998: 147) advise that when creating a central category (i.e., relating and subsuming the earlier made Core Categories), the explanation of the Central Category should be logical and consistent. There should be no forcing of data. Therefore, the names chosen for the Central Categories are more generic than the names given to the core categories, but their relatedness can be inferred. The four central categories created are:

- Information Environment
  This central category subsumes three Core Categories, namely: Core Category 1:'Information transfer facilitators', Core Category 4: 'Information relationships (intra-firm group level)', and Core Category 6: 'Information relationships (inter-firm group level)'.
- Supplier Potential
  This central category subsumes two Core Categories, namely: Core Category 2: 'Supplier capabilities', Core Category 1: 'Information transfer facilitators', plus a selection of codes (containing the word 'supplier') from the Core Category 3: 'Knowledge creation (intra-firm group level)', and from the Core category 5: 'Knowledge creation (inter-firm group level)'.
- Functional area staff
  This central category subsumes four Core Categories, namely: Core Category 3: 'Knowledge creation (intra-firm group level)', Core Category 4: 'Information relationships (intra-firm group level)', Core Category 5: 'Knowledge creation (inter-firm group level)', and the Core Category 6: Information relationships (inter-firm group level').
- Belief
  This central category subsumes two Core Categories, namely: Core Category 7: 'Trust' and Core Category 2: 'Supplier capabilities'.

According to Strauss and Corbin (1998: 146), a good test for the validity of Central Categories is whether and how the Central Categories explain what the research is about. Strauss and Corbin suggest that by using the Central Categories it should be possible to capture the essence of the research in just one sentence. Thus, coached in the terms of the Central Categories, the essence of the present thesis might be described as follows:

Beliefs about the potential of suppliers are an underlying factor in the information environment in which the functional area staff of customer and supplier firms meet and collaborate in the course of FFE of NPD.

Relating the above statement to the three Research Questions, it can be surmised that the utilization of supplier information and knowledge in the FFE of NPD will be influenced by whether or not the information environment in which the functional area staff work is conducive to the functional staff's believing in the capabilities of supplier firms.

3.8 Research quality

The present thesis applies two sets of criteria to evaluate the quality of its research.

- First, the positivist quality criteria for case research against which Beverland and Lindgreen (2010) assessed qualitative case studies published in Industrial Marketing Management in the years 1971-2006.
- Secondly, the (abridged) research quality criteria belonging to the critical realist tradition (adopted in the present thesis), and formulated for qualitative case research by Miles and Huberman (1994: 277-280).

Although the two sets of quality criteria represent two different theoretical paradigms, and deploy partly different terminologies (e.g., objectivity/conformability instead of construct validity), they share similarities in assessing rigour in qualitative case study research, as shown in Table 3.6.

Table 3.6 is organized in four columns. The first column lists the positivist criteria (Beverland and Lindgreen, 2010) with requirements for their operationalization. The second column outlines how these requirements were met in the present thesis. The third column lists the critical realists' criteria with query suggestions for the researcher to consider as formulated by Miles and Huberman (1994). The fourth column shows how these query questions were addressed in the present thesis.

The similarities between the two research traditions to case research quality are given by their requirements concerning the triangulation of sources of data, connecting research constructs to extant theory and literature, defining research population, and having in place validation checks by case study informants and coding checks. Lastly, both research traditions judge the research quality by consistency and traceability of case evidence that emerged from the Within-case and Cross case Analyses, by the researcher's effort to search for discrepant evidence, and by the presence of peer reviews.

The central issue of contention between the two research traditions concerns the generalizability of findings, that is, the external validity of case study research.

In the Critical Realist tradition, generalizability is referred to as transferability and is achieved by providing the reader with' thick' description of findings.

By 'thick' description is meant that the data are rich in detail (i.e., described in words), thus offering the reader a visceral experience (Stake, 2000) through which he/she can identify with the issues under study. In the Critical Realist tradition, a case study is valid if it contributes to the reader's understanding of the studied problem, but it does not aim to predict future applications.

In the Positivist tradition, external validity is related to replication logic (Yin, 2003), that is, whether the findings based on a chosen theory can be extended to other situations independent of time and context. A literal replication means that the new case has been selected to confirm the validity of the theory used in the original case. A theoretical replication seeks to find contrasting results for reasons that can be predicted from the theory of the original study (Yin, 2003: 47). Thus, evidence from multiple case studies is considered more valid.

The present thesis adopted a multiple case study design. The four cases, however, have not been selected to corroborate previous studies. Rather, the objective of the four case studies is to investigate through multiple perceptions of individuals working in the FFE of NPD the conditions under which supplier information and knowledge in four different contexts are exchanged, and to increase our understanding how supplier information and knowledge are utilized.

Next four chapters

Wolcott (1994: 55), in discussing his DAI composition formula (Description, Analysis, Interpretation) for a qualitative report, emphasizes that Description is at the heart of qualitative inquiry: "When we do not get much of it right, then what 'follows' does not really follow at all."

The description of a case begins with the Within-case Analysis. The next four chapters represent the Within-case Analyses of firms A, B, C, and D of the present thesis. Eisenhardt (1989: 540) holds a similar view as Wolcott (1994) when commenting on the descriptive character of Within-case Analyses:

> *The importance of within-case analyses is driven by one of the realities of case study research: a staggering volume of data. […] The volume of data is all the more daunting because the research problem is often open-ended. Within-case analysis can help investigators cope with this deluge of data. […] Within-case analysis typically involves detailed case study write-up for each site. These write-ups are often simply pure descriptions, but they are central to the generation of insight.*

The Within-case Analyses in Chapters 4-7, attempt to reduce the volume of data by creating three anchoring elements:

- First, the Salient Issues identified in the dyadic information relationships between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering of customer and supplier firms;
- Second, the Reflective Comments (placed in text boxes) regarding the Salient Issues – the first tentative assertions of the researcher; and

- Third, the tabular displays summarizing the Within-case Analyses concluding each chapter.

All four chapters have a similar structure. Each Within-case Analysis begins with a brief introduction to the external information relationships of the firm. This is followed by the main body of the analysis which addresses the dyadic information relationships at the micro-social level of the firm.

Positivist Quality Criteria (Beverland and Lindgreen, 2010)	Present thesis	Critical Realist Quality Criteria (Miles & Huberman, 1994)	Present thesis
Construct validity 1.Triangulation through multiple sources of data and interviews. 2. Providing readers with a chain of evidence using cross-case tables or quotes from informants. 3.Allowing interviewees to review the draft case and give comments	1.The multiple sources were company documents and e-mails, interviews, and direct observations . 2. Fig. 8.2 (procedures Within case Analyses & the Cross-case Analysis) and Fig. 8.4 (the Chain of evidence). Display matrices throughout the thesis.. Quotations are cross-referenced (i.e., traceable) 3. The informants received both the interview transcripts and case reports of their firms for validation.	**Objectivity/conformability** 1.Are the study's general methods and procedures described in detail? (including 'backstage' information? 2. Can we follow the sequence in data collection and processing? 3. Are conclusions explicitly linked with exhibits of displayed data? 4. Is there a record of the study's methods & procedures to be followed as an 'audit trail'? 5. Has the researcher been explicit about possible research bias? 6. Were rival conclusions really considered? 7. Are data retained and available for reanalysis?	1. Chapter 3: Research design and methodology; Questionnaire (Appendix 1) and Executive Summary (Appendix 2). 2. Chapter 3: Research design and methodology, Appendix 3 (Open and Axial Coding) and Appendix 4 (Selective coding). 3. The identified Salient Issues are linked to display matrices summarizing the findings of Within-case Analyses. 4.Atlas-ti database with coded interview transcripts, audio records of interviews. 5.Researcher bias is acknowledged in defining 'structural codes' and in identifying of Salient Issues. 6. Reflective Comments addressed supporting as well as conflicting case evidence and literature. 7. Atlas-ti database.
Internal validity 1.Pattern matching through cross-case analysis 2.Searching for negative cases, ruling out or accounting for alternative explanations. 3. Time series analysis**.**	1. The Cross-case Analysis in Chapter 8. 2. Reflective Comments throughout the thesis address supporting and conflicting evidence from the literature and case study data. 3. Time series analysis was not undertaken.	**Internal validity/credibility/authenticity** 1.How context - rich and meaningful (thick) are the descriptions? 2.Is the account a comprehensive one, respecting the configurations of elements in the local context? 3.Did triangulations among data sources produce converging conclusions? 4.Are the findings internally coherent; are concepts systematically related? 5.Were rules used for confirmation of propositions made explicit? 6. Were the conclusions considered to be accurate by original informants?	1.Extensive use of quotations in order to enable readers to vicariously experience the case (Stake, 2000). 2. The researched dyadic information relationships reflect the local dyadic information relationships. 3.Triangulation of data sources produced convergence and crystallization of evidence (Richardson, 2000) 4.The findings are comparable via display matrices. The data analysis is guided by RQ and the Conceptual Framework. Validation of RQ through Salient Issues and Multicase Themes. (Chapter 8.4) 5. The Cross-case Assertions about Multicase Themes have been explicitly related to the constructs of the Conceptual Framework (Chapter 8). The Multiple Themes analysed against the background of major scholarly works. 6. The text and conclusions of Within-case Analyses have been validated by the informants.
External validity 1.Specification of the population of interest. 2. Replication logic in multiple case studies.	1. Research population involved individuals in the function of (Design) Engineering, Purchasing, and Sales Engineering in the FFE of NPD. 2. Four case studies were undertaken.	**External validity/transferability/fittingness** 1.Are the characteristics of the original sample of persons, settings, and processes fully described to allow comparison? 2.Have limiting effects of sample selection been discussed? 3.Is the sampling theoretically diverse enough to encourage broad applicability? 4.Do the findings include enough 'thick' description for reader to assess potential transferability? 5.Are the findings congruent with, connected to, or confirmatory of prior theory? 6.Are the processes and outcomes described in the conclusions generic enough to be applicable in other settings?	1.Within-case Analyses in Chapter 4-7. 2.Research limitations in Chapter 9. 3.The studied dyadic information relationships can be found in most B2B firms. 4.The constructs of the reviewed Conceptual Framework are robust enough to allow for transferability to other contexts. 5. The findings are congruent with the theory of the Strength of Weak ties, and connected to the emergent theory of 'trusted weak ties'. 6. The applicability of Cross-case Assertions about Multicase Themes is limited by the research boundary of the FFE of NPD.
Reliability **1**.A standardized interview protocol 2.Constructs well defined and grounded in extant literature. 3.Providing and audit-trail by providing access to data.	1.An interview schedule of issues (Thomas, 2011) and a questionnaire. 2. Constructs defined in the Conceptual Framework based on Literature review (Ch. 2). 3. Atlas-ti database with coded interview transcripts, and audio records of interviews.	**Reliability/dependability/auditability** 1.Are the features of the study design congruent with RQ? 2.Were data collected across the full range of settings suggested by RQs? 3.Were coding checks made? 4. Were any forms of peer review in place?	1. RQs guide the data analysis. 2.Interviews were carried out with individuals in the functions stated in RQs. 3.Code checks were done using special features of Atlas-ti (e.g., code lists, code memos, code scope notes). 4.Monthly meetings with the thesis Supervisors.

Table 3.6 Quality criteria for case research

Chapter 4: **The Within-case Analysis of Firm A**

4. Introduction

Firm A is a tier-one supplier of electrical distribution systems for the aerospace and aviation industry, and is servicing orders from some 20 aerospace customers which include major aircraft manufacturers. The present case study explores the information relationships that Firm A enters into during the early stages of product development, either in its capacity as supplier or in the capacity as customer, but with no specific reference to the projects involved. The case study informants came from the Firm A's functions of (Design) Engineering (8), Purchasing (1), and from the function of Sales Engineers (6) of 'preferred' suppliers of Firm A. The figures in brackets indicate the number of participants.

The analysis of Firm A proceeds in two steps (Table 4.1). Step 1 describes the external information relationships of Firm A in general (Section 4.1), and offers the researcher's first Reflective Comments (Boxes 4.1 - 4.3). It focuses particularly on the external information relationships arising from the Firm A's order portfolio (Section 4.1.1), and on the external information relationships arising from R & D collaboration of Firm A (Section 4.1.2). Step 2 examines the information relationships of Firm A, in its role as customer, at the micro-social level. It analyses the interpersonal dyadic information relationships between the individuals working in three functional areas. Table 4.1 shows and Figure 4.1 illustrates the three dyads under study, namely:

- Suppliers' Sales Engineers / Customer's (Design) Engineers (Section 4.2.1);
- Customer's Purchasers/Customer's (Design) Engineers (Section 4.2.2); and
- Customer's Purchasers/Suppliers' Sales Engineers (Section 4.2.3).

The analysis is guided by the three Research Questions, and focuses on the What's, the How's, and the Why's/Why not's of these dyadic information relationships. Table 4.4 at the end of the chapter summarizes the findings. The analysis of each dyad concludes with the identification of Salient Issues (Boxes 4.4 – 4.13), based on the researcher's Reflective Comments about the found case evidence.

In turn, the Salient Issues (last column in Table 4.4), serve as input for the Cross-case Analysis in Chapter 8.

Table 4.1 Steps of analysis of Firm A

Step 1	External information relationships of the firm.	External information relationships of Firm A (Section 4.1) arising from the order portfolio (Section 4.1.1) and from R&D collaboration (Section 4.1.2)	**Outcome:** Reflective Comments made by the researcher on external information relationships. (Boxes 4.1 – 4.3)
Step 2	Micro-social level information relationships of the firm.	Information relationships of the three dyads of Firm A: Suppliers' Sales Engineers/ Customer's (Design) Engineers, Section 4.2.1; Customer's Purchasers / Customer's (Design) Engineers, Section 4.2.2; Customer's Purchasers/Suppliers' Sales Engineers, Section 4.2.3.	**Outcome:** Salient Issues in information relationships in each dyad, supported by the researcher's Reflective Comments. (Boxes 4.4 – 4.13)

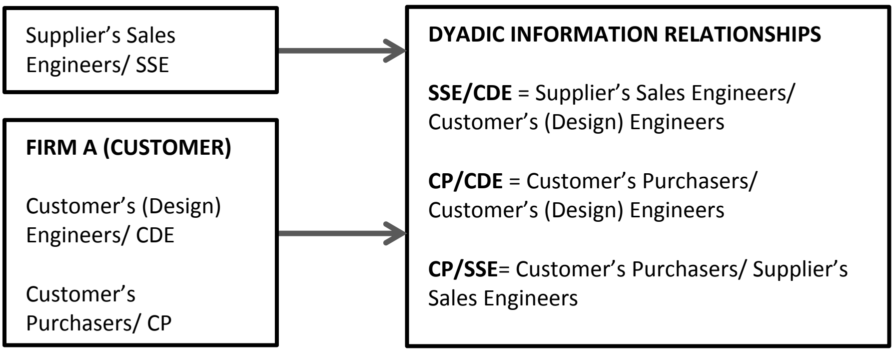

Figure 4.1 Schema of the case study of Firm A**.**

4.1 External information relationships of Firm A

The supply base of Firm A consists of some 180 worldwide supplier firms of which approximately twenty firms are responsible for supplying 80 per cent of 150,000 product parts (so-called 'items') that Firm A needs for the manufacturing of their advanced electrical distribution systems. The twenty suppliers have a long standing relationship with Firm A: the firm views them as 'preferred' or 'strategic' suppliers, and regularly invites them to participate in the upgrading or customizing of extant product parts. The external information relationships of Firm A are of two kinds: information relationships arising from the order portfolio (Section 4.1.1) and information relationships arising from R&D collaboration (Section 4.1.2).

The recurring theme in the case study is the transition that Firm A has made in the past ten years: from a manufacturer of electrical distribution systems (the build-to-print-orders) to Specialist in that field. In its role as Specialist, Firm A advises customers on the manufacturability (the build-to-requirements orders), or recommending to customers optimal cost design configuration (the build-to-specs orders) for their products. The case study informants ascribe this change in the Firm A's order portfolio to the accumulation of knowledge and expertise that Firm A had acquired, while supplying advanced electrical distribution systems to the world's biggest aircraft manufacturers. In consequence of this development, the nature of information relationships between Firm A and its suppliers and customers has also undergone a gradual change. Table 4.2 illustrates how a specific type of customer's order affects the information relationships that Firm A has with its respective customers and suppliers, and how it changes the scope of work of Firm A.

4.1.1 Information relationships arising from the order portfolio of Firm A

As shown in Table 4.2, in a build-to-print situation the information relationship of Firm A with customers and suppliers is one of commercial involvement. The customer mandates Firm A to purchase product parts from a Bill of Materials (BOM) defined by the customer. The product parts listed in BOM come for the most part from suppliers with whom the customer has had dealings before. For example, the Bill of Materials may contain the so-called proprietary parts (i.e., product parts that the supplier had specifically developed for that particular customer).

In consequence, the supplier has Intellectual Property rights over the proprietary parts and can set his own price. Occasionally, Firm A does have some say in negotiating the prices of product parts with suppliers. In such situations, the information exchange between Firm A and the supplier firm relates to commercial and operational issues and focuses on supplier performance. The price that Firm A subsequently charges to the customer is a ship set price of the final product which, in addition to the price of product parts, also includes the costs of engineering, manufacturing, shipping, etc. The Programme Manager of Firm A reflects that it is only when the manufacturing costs turn out to be higher than expected, that the customer will request Firm A to 'actively help' in finding ways to reduce the costs. Firm A responds to such requests by drawing the customer's attention to disparities in the existing supplier prices: *Yes, the costs could be lower, if you were to use product parts of this supplier instead of that one, and if you were to use standard parts instead of endorsing proprietary parts.* The situation becomes different in cases of build-to-requirements orders and build-to-specs orders. The build-to-requirements and the build- to-specs orders result in an information relationship that goes beyond commercial involvement because both parties engage in the exchange of knowledge. The Programme Manager attributes the growth in the 'build-to-requirements' and 'build-to-specs' orders to two factors.

Table 4.2 Information relationships arising from the order portfolio of Firm A

Customer's order to Firm A	Information relationship		Scope of work of Firm A
	Customer/Firm A (as supplier)	*Firm A (as customer)/Supplier*	
Build-to-print	The customer gives Firm A detail design drawings and a Bill of Materials (BOM). The customer sometimes even specifies from which suppliers the product parts should be purchased. Firm A manufactures the product.	Commercial involvement. Firm A purchases from the (specified) supplier the specified product parts. Firm A exchanges with suppliers commercially related information (e.g., prices, delivery times, order volume, etc.)	**Manufacturer**
Build-to-requirements	The customer gives Firm A the finished product design and technical requirements under which the product must function (e.g., in harsh environmental conditions in diverse aircraft zone areas). The task of Firm A is to assess the manufacturability of the customer design given the specified technical requirements. Firm A has a production approval.	Technical and commercial involvement. Meeting the specified technical requirements often requires product customization. Firm A exchanges knowledge and expertise with suppliers in adapting and qualifying existing product parts so that they function under specified environmental conditions. Suppliers provide input in the form of fully-functional samples for testing.	**Manufacturer with a production approval**
Build-to-Specs	The customer gives Firm A product specifications (specs), but Firm A can advise the customer on how to fill in the specifications. Firm A carries out trade studies to determine which product parts and cost design solutions (e.g., the configuration of product parts and the finishing techniques) best meet customer specifications. The final design responsibility is always with the customer.	Technical and commercial involvement. The exchanges of information and knowledge between Firm A and suppliers concentrate around trade studies (comparative tests) that Firm A performs on product parts available on the market. Suppliers provide input in the form of fully-functional samples for testing. The suppliers can be requested to come with proposals on how to improve their own products.	**Manufacturer with advisory capacity on product parts (SPECIALIST)**

The first factor is the growing recognition of the expertise of Firm A. The backbones of the expertise are the comparative tests on product parts, the so-called Trade Studies that Firm A continually carries out. Described by a customer firm as *'bread and butter'* of Firm A, the Trade Studies provide Firm A with a comprehensive overview of technical and physical properties of product parts available on the market.

The second factor behind the increase in the 'build-to-requirements' and 'build-to-specs' orders is the trend among customer firms to outsource their manufacturing. The outsourcing, however, as the Programme Manager notes, takes place only gradually and in small steps: *The customers say to us: "You are the Specialists", but they outsource only part of their manufacturing [to us], and keep a backup manufacturing plant of their own. It is only when the customers feel they can put their trust in Firm A that they start closing down their manufacturing plants.*

An example of how Firm A's knowledge grows in recognition is the 'build-to-specs' project that started in 2009. The project involved co-location of a team of some 30 (Design) Engineers from Firm A at the customer site. The (Design) Engineers of Firm A and the (Design) Engineers of the customer firm worked side by side to develop the functional and installation design of the electrical distribution system which Firm A was due to start manufacturing only in 2012-2013. A by-product of this form of early involvement in NPD is the forming of information relationships among the (Design) Engineers of the two firms. Knowing one's counterpart in the customer firm comes in useful during the production phase when the exchange of information between the (Design) Engineers of Firm A and the customer's (Design) Engineers need to be done quickly: *one does not ring up a total stranger any more.* The recognition of the Firm A's expertise is also evidenced from the fact that although the (Design) Engineers of Firm A were co-located at the customer site, they applied their own configuration design techniques, instead of the techniques of the customer, and that the customer actually endorsed this practice: *"You have most of the knowledge, it's your responsibility."* Being a recognized Specialist means that Firm A can in its dealings with customers and suppliers claim the role of a knowledge partner.

Firm A as a knowledge partner

Taking on the role of a knowledge partner requires adjustments in the way Firm A perceives its information relationships with suppliers and customers, and vice versa: how suppliers and customers perceive Firm A. The adjustments of all three parties are briefly described in the next paragraphs (each new adjustment is marked with <u>**</u>).

<u>**</u> The adjustment of Firm A to its new role involves learning on how to best effectuate knowledge sharing with customers. Historically, Firm A has always been partnering customers in their commercial operations because Firm A had the responsibility for controlling manufacturing costs.

However, in the situations of 'build-to-specs' or 'build-to-requirements' orders, the customer expects from Firm A more than manufacturing expertise. Firm A is expected to project its knowledge of manufacturing into the selection of product parts: to advise the customer on the technical advantages and disadvantages of product parts with regard to labour time, costs of assembly and installation, weight, and performance.

Moreover, Firm A is expected to introduce the customer to new technologies by adding new product parts to the customer's Qualified Parts List (QPL), a list of product parts that the customer had used in the past.

For new projects, the exchange of information and knowledge focuses on the Design Standard. The Design Standard is a compilation of proposed product parts, materials, and design configuration techniques that Design Engineers of Firm A and Design Engineers of the customer firm agree upon prior to starting a new project. The completion of the Design Standard involves extensive discussions between the two firms. The coordination is in the hands of a Senior Design Engineer who is an employee of Firm A, but who works at the customer's site. His job, in the words of the Programme Director, is: *To ensure that the selection of parts remains as close as possible to the product parts that the customer had worked with in the past, so that when we (Firm A) come with proposals for new product parts, we can fully focus on those, instead of having to go through hundreds of thousands of discussions about each product part one by one.* The fact that the Senior (Design) Engineer is co-located at the customer site attests to the intensity of information and knowledge exchange.

<u>**</u> The adjustment of supplier firms to the role of Firm A as a knowledge partner is reflected in the way they must reckon with Firm A's knowledge when approaching the customers of Firm A. It is no longer sufficient for suppliers to convince the customers of Firm A; i.e., the OEMs (Original Equipment Manufacturers), about the benefits of their offerings; suppliers now need to persuade Firm A as well. Moreover, the suppliers are becoming aware of the growing purchasing power of Firm A. The Chief (Design) Engineer of Firm A outlines a future scenario: *As we get more orders, we will be able to combine and apply the product parts across diverse Programmes, and as a result, we will order the product parts in large quantities. And then the supplier knows that if we were to order the parts from another supplier, he could lose a third of his market.* At present, however, the interviews with suppliers' Sales Engineers (all representing preferred suppliers of Firm A) indicate that, in their minds, Firm A is still predominantly a build-to-print manufacturer. This is reflected in the Sales Engineers' remarks, such as: *It can do no harm when information about our products comes from two directions: from myself to Firm A, and from my colleagues to the customer of Firm A.* Another Sales Engineer notes: *It is at the customers' site where the real product development happens.* Such remarks illustrate that in the triad 'customer-Firm A-supplier', the role of Firm A is not yet perceived as that of a full partner by supplier firms.

Another Sales Engineer describes the triadic relationship (his firm -customer-Firm A) as follows: *We are an OEM company, we develop products ourselves. We are not a reseller. We have closer relationships with aircraft manufacturers than Firm A, a sub-contractor, does have. Our goal is to be a tier-one supplier, because if we don't deal with aircraft manufacturers directly, but only with firms such as Firm A, we lose our business. Because the OEM's define exactly what they want, they define what functionalities they need in aircrafts. It depends on how critical the functionality is, whether you are talking to them directly or not. If it's of less importance, and* *somebody else in their supply chain is making the decisions, then they don't make it all themselves. So there is always a relationship between the OEM, strategic suppliers and the whole hierarchy below it. And we try to manoeuvre somewhere in-between, but always trying to be on top where decisions are being made.*

Sales Engineers have also drawn attention to the fact that Product Managers of their firms have often advanced knowledge of the needs of the aerospace industry because supplier firms are members of Standardization committees on which all major aircraft manufacturers are represented. Firm A has plans to join some of the Standardization committees as liaison members in the near future.

<u>**</u> The adjustment of customer firms to the role of Firm A (a tier-one supplier) as knowledge partner is reflected in the growing trust and reliance that customer firms place in the R&D capabilities of supplier firms. A (Design) Engineer of a customer firm is pleased about the development: *For us it is commercially interesting. The development of an aircraft is a lot cheaper if the product parts come from different parts of the world because these supplier firms pay for their R&D. The technology is not that different than if we were to produce the parts ourselves.* Thus, it can be concluded that for the time being, the knowledge reputation of Firm A is still foremost grounded in the manufacturing expertise. However, Firm A is deploying this expertise to further enhance its reputation as a knowledge partner in research and product development.

BOX 4.1

REFLECTIVE COMMENT

In Table 4.2, the customer's orders that Firm A receives are presented from the perspective of the resulting information relationships that such orders bring about. This perspective differs from those found in the literature. For example, Monczka et al. (2000) describe the diversity of customers' orders from the perspective of supplier integration in customer's product development (i.e., from the degree of design responsibility that the customer firm gives to the supplier firm in NPD). The benefits of co-location of (Design) Engineers for the exchange of information and knowledge, as used by Firm A in its relationships with customers and suppliers, has found support in the literature (Lakemond et al., 2006; Petersen, 2003; Schiele, 2012; Wagner and Krause, 2009).

4.1.2 Information relationships arising from R&D collaboration of Firm A

The R&D activities of Firm A concentrate on two areas (Table 4.3). The first area of research concerns the continuous improvement of manufacturing processes through the deployment of specially developed manufacturing tooling. The second area of research focuses on new material technology applications. The materials need to be lighter, cheaper, and last longer. The motivation of Firm A to engage in research is driven by the desire to stay competitive, and to continue to uphold the Firm A's reputation as Specialist. The Chief (Design) Engineer puts it this way: *You cannot walk away from your responsibility*. Therefore, Firm A is continually on the lookout for improvements in their manufacturing operations: how to make the manufacturing process more efficient in terms of time, costs, and maintenance.

Table 4.3 Information relationships arising from R&D collaboration of Firm A

Innovation Initiative of Firm A	**Information relationship**		**Outcome**
	Motives of Firm A	*Suppliers involvement*	
Manufacturing tooling	Firm A continually improves the efficiency of its manufacturing process by cutting down manufacturing time and costs.	Suppliers and Engineering Bureaux are invited to help develop manufacturing tooling that makes the manufacturing process less time consuming and less labour intensive.	Tooling machine (a case vignette)
Material technology & choice of R&D partners	In order to stay competitive, current material technology needs to be upgraded; new material applications developed to meet new sharper weight targets.	Suppliers and research institutes are invited to think with Firm A about new technology development and applications.	A strong preference for partners outside the supply chain. (confidential projects)

Manufacturing tooling (a case vignette)

The development of the tooling machine dates back to a suggestion made by a major aircraft manufacturer to Firm A that Firm A ought to purchase the same tooling machine that the aircraft manufacturer had. At that time there was only one type of machine available on the market. The tooling machine enabled to speed up a certain phase in the manufacturing process that until then had to be done manually, and was labour intensive.

Firm A examined the machine but was not impressed with its capabilities, and decided to write down its own specifications. The Project Engineer then started to look for an innovative tooling manufacturer who would be interested in developing a tooling machine according to Firm A's specifications, and at reasonable costs. None of the tooling suppliers approached were interested, because the potential order involved just one piece of machinery. Eventually, a Google search identified a website of an engineering bureau that, according to the website, had in the past done business with a sister firm of Firm A, situated within walking distance of Firm A.

That fact alone already evoked some trust. But the Project Engineer made further inquiries at the sister firm of Firm A about the Engineering Bureau. Having received positive reports from the sister firm, the Project Engineer phoned up the Engineering Bureau: *You are already working for our sister firm. Let's meet to discuss whether we could mean something for each other as well!* At the orientation meeting the Engineering Bureau presented the portfolio of their projects for the sister firm of Firm A. On the basis of this presentation, Firm A decided to hire the Engineering Bureau, and the Engineering Bureau signed a non-disclosure agreement (NDA).

The design process involved a detailed analysis of the manufacturing process, numerous tests, and extensive periods of co-location of the Engineering Bureau staff at Firm A. The result was a one of a kind tooling machine that is 24 hour computer-controlled and combines two handling steps in one. For Firm A, the tooling machine represents a substantial competitive advantage: it meets the industry qualification criteria, and the competitors do not have such a machine.

BOX 4.2

REFLECTIVE COMMENT

The recommendation of the sister firm, a third party referral (Wang et al., 2005), played a decisive role both for Firm A and the Engineering Bureau. Ultimately, trust between Firm A and the Engineering Bureau was mediated on the one hand by the social ties between Firm A and the sister firm of Firm A, and on the other hand by the social ties between the Engineering Bureau and the sister firm of Firm A. For the Engineering Bureau, a third party referral established the bureau's legitimacy (trustworthiness), of which they took full advantage during the first meeting with Firm A. During the presentation of past projects, the bureau focused exclusively on projects that they did for the sister firm, and not, for example, on projects that they did for other firms.

The social ties between Firm A and the sister firm could be described as a strong tie (family) relationship (Granovetter, 1973, 1982), whereas the relationship between Firm A and the Engineering Bureau with its focus on novel information and trust can be said to reflect a trusted weak tie relationship (Levin and Cross, 2004).

Material technology

With the growing recognition of their role as Specialist, Firm A has been regularly getting inquiries from customers about how to make product parts lighter so that the customers can meet and better manage the required weight targets. It was in response to such requests that Firm A instigated research projects on light-weight material technology. The Project Coordinator outlines the reasons for this step: *We realized that we often had ideas for product solutions, but that the technology was not mature. The idea behind our R&D projects is to anticipate customer needs, and to initiate innovations so that when the customer* *asks for new product solutions, we can offer new technology that is mature; i.e., technically feasible and cost effective.* The research projects are confidential, and will therefore not be further discussed here. However, what is interesting in the context of the present thesis is the selection of research partners.

Choice of R&D partners

Firm A manufactures advanced electrical distribution systems for some 20 aircraft builders. Therefore, Firm A is in good position to overview the product development needs throughout the industry. At present, however, Firm A has modest research facilities. In contrast, the preferred suppliers of Firm A have extensive research facilities, years of experience in research, and they reserve each year a substantial part of their Revenue on Sales for research. Consequently, setting up research projects in partnership with preferred suppliers might seem like an obvious option for Firm A. This is, however, not the case. Firm A does not regard supplier firms as a first choice for research cooperation. In fact, Firm A purposefully seeks their research partners outside the supply chain. The current research projects are done in cooperation with universities and research institutes. The financing of such projects comes for one third from Firm A, and for two thirds from government grants. The reasons for choosing academic institutions over supplier firms are twofold, as the following comments made by the Chief (Design) Engineer illustrate.

Firstly, the suppliers are developing product parts only, whereas Firm A is interested in a larger picture of material technology. *When you manufacture a product, it's not just the elements themselves which you have to consider. It's the parts around them, how you manufacture them in the first place. And sometimes you improve the product and sometime you improve the manufacturing element as well. So it's not only the technology of the element, but how you put it together.*

Secondly, universities and research institutes have no commercial interests, and are more open minded; they think across industries. Therefore, Firm A expects breakthrough research to come from academic institutions rather than from suppliers. *You are not restricted to what suppliers think is a solution at that point. You can think beyond their current products. If you talk with the suppliers they will probably, or very likely, give a solution within a remake of their current product sphere.* However, the interviews with the suppliers' Sales Engineers revealed that supplier firms did in fact engage in long term research.

The projects that the Sales Engineers mentioned concerned, for example, the research on tidal energy (renewable energy obtained on coasts, based on the sea or ocean low and high tides), and the research on expanded beam lens technologies. For both projects the supplier firms entered into a strategic alliance with other firms. Questioned about a possible R&D cooperation between suppliers and Firm A, the answers of Sales Engineers became cautious: *It depends on the project. But that is not the basis for our relationship, and I don't think that it's the intention of Firm A either to approach it that way. The key for Firm A is to have the best possible product for the cheapest price; a product which can be handled in the most efficient way.*

The Sales Engineer sums up the dilemmas between the importance of Sales and the commitment to R&D as follows: *Of course, at the end we want to sell our products. But at the same time our technology team tries to orient the mind of each team member to the needs of the market, to find technical solutions.* Another Sales Engineers describes the problem solving initiatives of his firm's R&D departments in similar terms, when he talks about anticipating future product applications, looking for niche markets, picking up concerns about environmental properties of materials: *Cadmium plating has been under fire for some time. There has been a lot of discussion about it, but now it's a legally binding ban. So we needed to come up on time with an alternative anti-corrosion coating.*

The main stumbling block in the cooperation with suppliers concerns the issue of Intellectual Property (IP) rights. The Senior Design Engineer stressed the importance of having the IP agreements in place. *Aircraft manufacturers are sometimes loci for gratuitous product development for suppliers. When a supplier develops a special product part at the request of a customer, the costs (tooling costs, certification procedure costs, etc.) are paid for by the customer. Unless there are restrictions on the product (e.g., non-disclosure agreements, IP rights, etc.), the supplier can proceed to develop the product further and eventually bring a whole new product line on the market without having incurred too much costs.*

BOX 4.3

REFLECTIVE COMMENT

The case evidence suggests that at present neither Firm A nor supplier firms have confidence (trust) in each other's research endeavors. Firm A fears that supplier research activities lack the scope and impartiality that Firm A needs. Suppliers, in their turn, don't consider Firm A as a suitable research partner because they don't believe that research is a core activity of Firm A.

The preference of Firm A for R&D partners from universities has been substantiated by research (Knudsen 2007). A survey of European manufacturing and services and their innovation-related knowledge flows, covering seven countries and five industries, found that R&D relationships with universities had a positive effect on generating original ideas. However, the survey also found that only 11.5% of the firms engaged in such collaborative relationships.

4.2 **Micro-social level information relationships of Firm A**

The previous sections (Section 4.1 – Section 4.1.2) described the external information relationships of Firm A. The next sections discuss the information relationships of Firm A (in the role of customer) at the micro-social level, that is, within interpersonal dyadic relationships.

The case study informants came from (Design) Engineering (8) and Purchasing (1) of Firm A, and from Sales Engineering (6) of 'preferred' suppliers of Firm A. The figures in brackets indicate the number of participants for each group.

The dyads found operating in Firm A are:

- Suppliers' Sales Engineers / Customer's (Design) Engineers dyad (Section 4.2.1)
- Customer's Purchasers /Customer's (Design) Engineers dyad (Section 4.2.2)
- Customer's Purchasers /Suppliers' Sales Engineers dyad (Section 4.2.3)

The three dyads are analysed in terms of the What's, the How's and the Why's/Why not's of their information relationships, thus following the Research Questions. Table 4.4 provides a summary of the analyses.

The analysis of each dyad concludes with the identification of Salient Issues (shown in the last column in Table 4.4), and is supported by the researcher's Reflective Comment on the evidence found. The Salient Issues, in their turn, are the input for the Cross-case Analysis (Chapter 8).

4.2.1 Suppliers' Sales Engineers/Customer's (Design) Engineers dyad (SSE/CDE)

Of the three dyads, the information relationship between Suppliers' Sales Engineers and Customer's (Design) Engineers has the greatest influence on whether or not, and how, supplier information and knowledge will be utilized. Here is, however, important to note that the case study informants were not familiar with the concept of social ties and their facilitating role in information relationships. In consequence, the informants were hesitant to describe their information relationships in those terms. The only straight characterization with regard to social ties came from the Chief (Design) Engineer: *Generally, the people on the list (i.e., the names mentioned in the research questionnaire) are trusted weak ties at the moment […]. The people from […] department up until recently were also a trusted weak tie, but it's a strong tie now, because I have arranged regular sessions with them. […] Suppliers are trusted weak ties.* Fortunately, the interviews with the informants provided enough evidence about the formation of dyadic information relationships and the function of social ties therein.

The next paragraphs discuss six manifestations of information relationships between suppliers' Sales Engineers and customer's (Design) Engineers in Firm A, namely: Trade Studies, Hand Tool Development, Integrated Product Teams, Identifying New Supplier Technologies, the Bill of Materials (as an information source), Sounding Board, and Visits to supplier manufacturing sites. The discussions are organized into sections addressing the What's, the How's and the Why's /Why not's of the information relationships.

Trade Studies

WHAT

Trade Studies are comparative tests that Firm A performs on diverse product parts that are available on the market and product concepts under development. The Trade Studies present evaluations of the available product part alternatives in order to arrive at low-cost design approaches.

HOW

The Trade Studies streamline the product parts by making them comparable. Suppliers' Sales Engineers provide input in the form of functional product samples. The Senior (Design) Engineer describes the process: *We get samples of product parts of all shapes, and sizes or formats. The Trade Study makes the product parts comparable by evaluating them against a standard set of criteria. This means that the information coming from the Trade Studies can be directly applied in the detail design phase.* The criteria cover the technical and physical properties of product parts (e.g., weight, size, material used) and their price (provided by the Purchasing department). Furthermore, the Trade Studies focus on how to optimize design costs from the perspective of Firm A. For example, how to optimize the ease of assembly and the amount of labour time needed. The Trade Studies are an on-going activity that the (Design) Engineers of Firm A carry out in addition to their regular work. The results of Trade Studies are included in the Preliminary Design Review (PDR), together with the reasons why a particular product solution had been given preference, or had been rejected (the so-called 'lessons learned'). Before setting up a new Trade Study, old Trade Studies are checked for reference.

WHY

The Trade Studies can be utilized in three ways.

Firstly, Trade Studies make recommendations to the customer as to which product parts best meet his specifications and requirements. The Chief (Design) Engineer points out that the recommendations are not binding: *The customer will see a Trade Study of different options, and then he will see that there is a preferred option being proposed to him at that point, and then we explain why it is a preferred option. And hopefully that one is selected at that point, or there is a discussion, and another option is selected for another reason.*

Secondly, Trade Studies qualify product parts. This is especially the case for the 'build-to-requirements' orders where the customer provides a full product design, with technical requirements concerning the conditions under which the product must function (e.g., harsh environmental conditions in certain aircraft zone areas). In such cases, Firm A has a production approval which means that it is responsible for the manufacturability of customer's product designs, and the product performance under specified conditions. To meet these specified requirements, the product parts often need to be customized or 'ruggedized', meaning that Firm A needs to adapt the existing product part in such a way that it can function under the specified conditions. The new product part is then tested and qualified by Firm A. In such situations, the exchange of information and knowledge between the (Design) Engineers of Firm A and the suppliers' Sales Engineer (who liaises extensively with the Engineers of his/her firm) focuses on the possible manufacturing and material defects. Thirdly, Trade Studies test new technologies in order to see whether they are eligible for submission to the Qualified Parts List (QPL) which is maintained by the US Department of Defence, and on which customers base their own QPLs. The Senior (Design) Engineer explains the value and function of the QPL: *The QPL identifies product parts that are manufactured to stringent military specifications. To determine compliance, the product parts are subject to strict testing. If suppliers don't meet the military specifications, their products can be removed from the list. The QPL is a strong quality control mechanism.* The supplier's Sales Engineer notes: *For us, it is important that our products are listed in the QPL; it is a kind of reference.* As a rule, customers start a Programme with a QPL based on previous Programmes. However, the customer expects Firm A to propose new technologies that can be added to the list: product parts that are lighter, smaller, and cheaper. Trade Studies can be the stepping stone to product part qualification.

WHY NOT

Despite the information value of Trade Studies, their utilization in Firm A is not optimal. The Trade Studies are filed together with PDR (Preliminary Design Review) reports and can therefore be accessed for reference. Currently, there is no formal mechanism through which the information is shared or disseminated throughout the firm, and across Programmes. Thus, at present, the Trade Studies and the mandatory section 'lessons learned' in the PDR represent a static type of information exchange. It is a problem that the informants from both the supplier firms and Firm A recognize.

A supplier's Sales Engineer, for example, noted with surprise that he often had to tell the same story twice: *I can tell one account team about a new product but I can never be sure that the information will be passed on to another team.* Some informants remarked that the exchange of information seemed to happen easier among the younger generation because they were probably more 'open-source minded'. Other informants pointed out that it's not just a question of passing on the information but also the manner in which it is done: *Some people can explain things very well; but others can actually demonstrate how to tackle a particular problem.* Firm A has a matrix organization structure which in theory should facilitate and stimulate information sharing as (Design) Engineers relocate across Programmes. In practice, however, the sharing of information is incidental, and governed by social relationships in which people are willing to make time and share information with each other.

BOX 4.4

REFLECTIVE COMMENT

The value of Trade Studies is twofold. First, the Trade Studies represent a comparative source of tangible supplier knowledge in the form of products that suppliers bring to the market. Trade Studies demonstrate that physical products can serve as information products during the design stage (Von Hippel, 2006). Secondly, Trade Studies record the engineering solutions that Firm A had tried out, or adopted, in diverse design configurations. The case evidence suggests that demonstrating a particular technology application in a face-to-face meeting is conducive to the exchange of information and knowledge. Often such exchanges are more effective when they take place through informal social mechanisms rather than through formal information channels, such as NPD meetings, that had been set up for that purpose (Cross and Sproull, 2004; Lawson et al., 2009). The research on information seeking behaviour of (Design) Engineers has repeatedly shown the that (Design) Engineers attach importance to personal contacts, because that way they get an immediate feedback on the design application context that they are involved with at that moment (Allen, 1977, Fidel and Green, 2004; Hertzum and Pejtersen, 2000; Hirsh and Dinkelacker, 2004).

SALIENT ISSUE: **Information and knowledge exchange through social ties.**

Hand tool development

WHAT

The Area Manager in Manufacturing reported that installation of a product part was particularly difficult and time consuming. A certain step in the installation process required the use of three hands (i.e., the Operator needed assistance from a colleague). The Chief (Design) Engineer put the problem before a Sales Engineer of one of the preferred suppliers of Firm A.

HOW

The Sales Engineer responded by forming a team of (Design) Engineers from his firm and coming to study the problem on the production floor of Firm A. In all, the supplier technical team visited Firm A three times, and within four months the team presented a mock-up of the tool that could be handled with one hand thereby saving 15 minutes on assembly time.

WHY

When questioned as to why he had chosen that particular preferred supplier over others, the Chief (Design) Engineer replied: *They have a more positive attitude to this kind of questions. You can discuss a problem with them without having to take out your wallet first, as is the practice with the suppliers who look only for commercial benefits. The new tool is expensive but allows for easy maintenance and modification of our product which is especially useful in the pre-series phase.*

An interview with the supplier's Sales Engineer revealed that it was not the first time that his firm had developed a tool following a request from a customer. A few years earlier the firm developed a similar tool for a major aircraft manufacturer. At that time, the supplier firm had even to develop a machine for manufacturing the tool, as there was no such equipment on the market. The Sales Engineer explains the business case behind the tool development as follows: *The goal is to provide more service to our customers, and that way to sell more of our products, of course. And we do that because with the service we gain a competitive advantage over our competitors. We have been one of the first firms to adopt that approach. Generally speaking, we make profit on our products, not on tools. So when we develop a tool, we at least try not to lose money. We sell the tool at the cost price. We make a short and simple business case so that we understand how long it will take before we have a zero payback on that kind of product.*

WHY NOT

Reflecting on the tool development history, the supplier's Sales Engineer adds one more precondition that needs to be in place in order to have a successful project: *We cannot fulfil all the requests. We can only work with companies with sufficient engineering background. We need to have questions that are technically well-grounded and to work with companies at the engineering level. We need to have a clear definition of the need, to know the direction in which the improvement is needed. With smaller companies you would never be able to produce something that would become a standard product.* The fact that the hand tool helps cut down installation time has not gone unnoticed. A major aircraft manufacturer has included the hand tool in its Installation Guide.

BOX 4.5

REFLECTIVE COMMENT

Having a business case is not enough for a project to succeed. The Hand Tool project is about how Firm A and the supplier firm exchanged information and knowledge regarding performance requirements for a new hand tool. To be effective, the exchange of information and knowledge needs to have a certain relational quality (i.e., be embedded in social relationships conducive to the exchange). Relational embeddedness (Granovetter, 1973, 1982, 1985; Uzzi, 1996, 1997) is a quality dimension of social relationships expressed through social ties between the parties involved in the exchange process. The properties of social ties can vary in strength and content. The supplier's Sales Engineer specifically refers to *sufficient engineering background* and to *technically well-grounded questions*. In other words, for a project to succeed, the project participants need to share a common knowledge base, and the exchange of knowledge needs to be embedded in social relationships that support the (Design) Engineers in their task.

SALIENT ISSUE: **Knowledge properties of social ties.**

Integrated product teams

WHAT

The exchange of information and knowledge between Firm A and a supplier firm can take place within an integrated product team (IPT). The IPT brings together Engineers and Purchasers from Firm A and the Sales Engineer and (Design) Engineers of the Supplier firm. In such situations, Firm A involves suppliers already in the conceptual and detail design phase of product development.

HOW

Firm A requests a supplier firm to help develop a product part that would be a derivate of the supplier's extant product, but that could withstand harsh environmental conditions. Firm A defines the product specifications, writes down the statement of work for the supplier firm, and forms an integrated product team (IPT). The progress of work is monitored through action lists during the weekly teleconferencing sessions chaired by Firm A. The supplier's Sales Engineer describes the information exchange as follows: *Of course you see that in practice not all actions are closed at the dates set. But as long as you explain why it happened, and you can agree upon a new date, then it's OK. At least you have a piece of paper on which you all agree. And then you have a whole week to arrange your stuff.* The supplier firm tests and qualifies the product and becomes a sole manufacturer of the product. Since the product has been specifically developed for and paid by Firm A, the qualification data remain with Firm A. The product part is not listed in the supplier's product catalogue, but the supplier is free to sell the product to other customers.

WHY

Firm A engages in such cooperation in order to get a lead time advantage. Although the supplier can still sell the product to other customers, this is not an issue with Firm A. The Senior (Design) Engineer explains*: What matters to us most is the fact that the supplier is the only manufacturer of the product part. Our competitors can buy the product part but they need to qualify it first before they can use it. And that takes time, as the qualification process often takes longer than the actual product development. So, if a customer needs to have that particular product part quickly, he must come to us because we have qualified the part. We can meet lead time requirements, whereas our competitors cannot.* The supplier's Sales Engineer interprets the status of his firm as a sole manufacturing source as follows: *Obviously, the goal of every customer is to have no single source item. But you can imagine that they (Firm A) have invested a lot of effort with us to get a qualified part, and would have to do the same with another supplier, and they simply don't have enough time and money to do that. They are under so much pressure to get a qualified part, just in time for the production, so that they need to work with one preferred supplier only. And, luckily, that's us.* Interestingly, the decision to work as an IPT team was a deliberate joint decision of the Senior (Design) Engineer of Firm A and the supplier's Sales Engineer who both wanted to forestall a repetition of the problems that they had encountered in previous projects.

The supplier's Sales Engineer comments: *With the IPT meetings I felt that we were one of the few that Firm A trusted in that field, that they could talk to. In most cases our products are not the cheapest ones. But it's not only the price. We deliver support and service and that costs money. So Firm A knows that there is a certain value attached to the service we offer. On the other hand, we now also solve their issues in order to meet their schedule. Firm A had a problem and found in us a partner who can help solve the problem. And they trust us.*

BOX 4.6

REFLECTIVE COMMENT

Sole sourcing (i.e., a product part is manufactured by one supplier only) represents for Firm A a lock-in situation. At the same time, the cooperation between Firm A and the supplier firm results in benefits for both firms. The cooperation is rooted in trust which consists of two elements.

The first element is the presumed goodwill of the supplier firm. This is best demonstrated by the willingness of Firm A to start up a new project with the supplier firm although a previous project did not work out well. The manifestation of goodwill is also apparent from the fact that both parties are prepared to learn from past mistakes.

The second element is the Firm A's trust in the supplier's competence (augmented by supplier's support and service). Taken together, these two elements formed the basis behind the decision to start up a joint product development project.

Sole sourcing by its very nature brings the customer firm and supplier firm closer together. The literature mostly takes a negative view of such dependency because of the absence of price competition. However, a close relationship with the supplier can also have positive effects (Treleven, 1987; Zeng, 2000; Ulaga and Eggert, 2006). One such positive effect can be joint product development. The case evidence from Firm A suggests that at the level of Suppliers' Sales Engineers / Customer's (Design) Engineering dyad, the disadvantages of a lock-in situation are weighed against the benefits of competitive advantage that both parties accrue from joint new product development.

SALIENT ISSUE: **Sole sourcing and information and knowledge exchange.**

Identifying new supplier technologies

WHAT

Firm A learned about a new piece of technology during a supplier product presentation held at Firm A, and decided to include the technology in a customer's Programme in the future. The Sales Engineer of the supplier firm recalls the presentation: *Firm A was really interested in our new technology, but did not discuss any specific application with us at the time. And we did not know that they were bidding for an order from an aircraft manufacturer. But when they won the order, they got in touch with us and said they would like to include our technology in the Programme.*

HOW

The supplier firm agreed to adjust the new technology so that it would fully meet the requirements of the Firm A's customer. Diverse samples of product mock-ups were exchanged, tested, and discarded; engineering solutions were compared and test reports evaluated. The discussion lasted several months and focused on the properties of the new technology, the customer's requirements, and the arising manufacturing issues. When Firm A and the supplier firm arrived at an understanding as to how the new technology could be used in the Programme, they joined forces in approaching the Firm A's customer in order to explain the benefits of the new technology.

WHY

The supplier firm and Firm A depended on each other's support to deal with the customer's questions. The supplier firm needed Firm A to recommend its product to the customer, but at the same time Firm A lacked the detailed supplier knowledge regarding all the safety issues of the new technology to explain to the customer. Together, the three parties, 'the supplier-Firm A-the customer', represent a triad of interests. The supplier's Sales Engineer describes the interplay of interests as follows: *As soon as you make a new step in technology, you need to make people confident about the safety issues. You need a strong argumentation, and for this you need support which we can provide. If there are technical issues, we have a technical team that will react and make corrections. The end customer must be confident that he can take that new step in technology.*

BOX 4.7

REFLECTIVE COMMENT

The implied trust in the exchange of information and knowledge can take different forms. Lewicki and Bunker (1996) developed a model of trust development in working (professional) relationships. The model consists of three transitional stages: calculus-based trust; knowledge-based trust; and identification-based trust. The three types of trust are linked in a sequential iteration in which achievement of trust at one level enables the development of trust at the next level. The above example represents the stage of identification-based trust, the highest level of trust development. Firm A and the supplier firm have a common goal: they are partners in product development for the same customer. They depend on each other for the success of the project. They identify with each other's needs and preferences with regard to introducing this new technology in the customer's product. This mutual understanding of each other's position is the outcome of an extensive exchange of information and knowledge that was reached in the preceding stage of trust development, the stage of knowledge-based trust (the stage in which the Engineers of Firm A and the Engineers and Sales Engineers of the supplier firm were discussing the new technology).

SALIENT ISSUE: **The role of trust in information and knowledge exchange.**

The Bill of Materials (as an information source)

<u>WHAT</u>

An Expert Manufacturing Engineer of Firm A developed at home, in his free time, a mock-up of a product part that combined engineering solutions that he had seen in the Bill of Materials in two different Programmes. The Expert Manufacturing Engineer then approached the Purchasing department of Firm A and requested that they would find a supplier firm to manufacture the new product part.

<u>HOW</u>

The Purchasing department contacted the Sales Engineer of one of the preferred suppliers of Firm A. After inspecting the mock-up, the Sales Engineer commented that the mock-up reminded him of a product part that he had seen before. When the Sales Engineer checked with the (Design) Engineers of the firm, it turned out that the same product part had been produced by his firm half a year earlier. Since the product part was developed at a customer request, it was not listed in the supplier's catalogue.

<u>WHY</u>

When the Purchasing Manager was questioned about why he had contacted that particular supplier (instead of any other of the twenty preferred suppliers), he replied: *It was intuitive. I know that they make that kind of product parts. Besides, a similar solution has been applied in another Programme. I would not have done my work well, if I had not turned to this supplier first.* Several informants from Firm A recounted this incident as an example of the unexploited potential of supplier knowledge. Recollecting the incident, the Programme Manager said: *What stuck in my mind was the remark of the Sales Engineer that what was listed in the product catalogue represented only 10 per cent of his firm's product offerings.* As a tier-one supplier of advanced electrical distribution systems to the world's biggest aircraft manufacturers, Firm A is in a position to overview the Bills of Materials (BOM) used in different Programmes. In the words of the Chief (Design) Engineer of Firm A: *Politically, it may be difficult to say, but you are exposed to different ideas for solving a problem, and you can then look whether the idea is commercially available (if you think it's a good solution), or you may stimulate a follow-up on the idea. I don't think that solving it that way is that unusual.*

BOX 4.8

REFLECTIVE COMMENT

The case informants saw in the incident of the 'new' product part a manifestation of how much more there was to know about supplier offerings. The incident, however, also brings to light the shortcomings in the information relationship between the Expert Manufacturing Engineer and the Purchasing department. Had the Purchasing department been approached earlier, the whole incident needn't have happened.

SALIENT ISSUE: **The strength of social ties.**

The 'sounding board'

WHAT

A customer firm requests Firm A to act as a 'sounding board' for its new product ideas. The customer firm knows Firm A from past projects, values the expertise of Firm A, and is aware of the network of contacts that Firm A has with suppliers. Firm A advises the customer on specifications for the customer's new product concepts that are not yet connected to any specific project.

HOW

The contribution of Firm A consists of validation trials (paid for by the customer firm) of product parts that are new to the market but that have as yet not been qualified. The purpose of the validation trials is to discover whether the benefits of the new parts are indeed such that the customer should take steps (time and money) to qualify them.

At the request of the customer, Firm A seeks out suppliers that would be willing to manufacture product samples according to the customer's specifications. The supplier firms that agree to participate, however, do not know how many other supplier firms had been approached by Firm A, and they also do not know the identity of the customer from whom they will be manufacturing the product samples. The Senior Design Engineer motivates this approach as follows: *To bring the suppliers together makes no sense because it would result only in one joint design. Dealing with each supplier separately means that each supplier comes with their best ideas.*

Interestingly, the contacts with suppliers occur through the Purchasing department of Firm A, and not through (Design) Engineering. A staff member of Purchasing sits together with the (Design) Engineers on telecom meetings with the customer. Firm A performs its work as a 'sounding board' at cost price (i.e., the number of engineering hours spent). Such projects have no time limit and no project boundaries, which fits better with the character of an innovation project. In the words of the Senior (Design) Engineer: *If it is done quickly, it is bad. The ideas need to mature, to go back and forth among the three parties: the manufacturer, Firm A, and the supplier.*

WHY

For supplier firms, such projects represent a learning opportunity: through the manufacturer's specifications they learn about the needs of a potential customer. Should the product part concept turn out to be technically and commercially feasible, then the supplier firms expect to get the order for that particular product part. Firm A has similar motives: the projects represent a potential business opportunity, such as future orders from the manufacturer.

BOX 4.9

REFLECTIVE COMMENT

The Firm A's customer, Firm A, and the invited suppliers have regular exchanges of information and knowledge. The exchange partners learn what they can expect from each other. For example, Firm A learns about how suppliers react to a request to manufacture product samples. The customer learns about the capabilities of Firm A in finding interested suppliers. Lastly, the participating suppliers learn about future directions in product development. Lewicki and Bunker (1996) speak of 'courtship'. The outcome of the exchange of information and knowledge affects the decisions about potential cooperation in the future.

SALIENT ISSUE: **The exchange of information and knowledge as business courtship.**

Visits to supplier manufacturing sites

WHAT

The recurring theme in the interviews with supplier's Sales Engineers is the way the Sales Engineers describe their job as *connecting engineers with engineers.*

HOW

The supplier's Sales Engineers regularly invite the customer's (Design) Engineers to visit supplier plants, and supplier's R&D labs.

WHY

The motives for and the outcomes of such visits vary. Of course, the first objective is to acquaint the customer's (Design) Engineers with a wider range of the supplier's products. However, there is also an educational element in these visits.

In the words of one supplier's Sales Engineer: *Some (Design) Engineers have never seen a production plant. They work with our product parts in the CATIA design environment, but it is good for them to come into physical contact with the manufacturing process.* A Senior (Design) Engineer has this to say about visiting supplier plants: *I learn from it. Sometimes the products are handy, and you can use them, sometimes you just thank for the information. But it's always good to know what's available.*

A (Design) Engineer points out yet another benefit in visiting supplier sites: *If anyone has to take decisions on contracts or technical decisions, you have to know how the product part is made, and what the background is. What you need to understand is that a product part is made of several components. If you hear that one component went up in price by 40% than the price increase only applies to that particular component and not to the whole product part!*

BOX 4.10

REFLECTIVE COMMENT
The visits to supplier sites are formal events. A supplier's Sales Engineer issues an invitation to the customer's (Design) Engineers and makes arrangements for them to see and meet their counterparts at the supplier's site. At the same time, such events lead to informal exchanges of information and knowledge, and to establishing social relationships. The customer's (Design) Engineers learn how the products they work with are made, and they meet the people that make them.

SALIENT ISSUE: **The supplier's Sales Engineer as a social mediator between his/her firm and the customer's (Design) Engineers.**

4.2.2 Customer's Purchasers / Customer's (Design) Engineers dyad (CP/CDE)

The information relationship between Purchasers and (Design) Engineers in Firm A focuses on the selection of product parts (and their suppliers), and on initiating cost savings drives (the so-called Affordability initiatives). In both activities Purchasers and (Design) Engineers cooperate closely, and take the decisions jointly.

The circumstance of joint decision making can be largely attributed to the fact that Firm A purchases product parts directly from suppliers. In firms where the purchasing is done through distributors as, for example, is the practice in a customer firm of Firm A, then the relationship between (Design) Engineers and Purchasers is more distant. The decisions about product parts are taken sequentially rather than jointly, with (Design) Engineers initiating the purchase.

The next sections discuss the information relationships between Purchasers and (Design) Engineers of Firm A in the context of product Part selection and Risk assessment, and in the context of Affordability initiatives.

Product part selection and risk assessment

WHAT

The main concern of Purchasing with regard to the selection of product parts is to avoid single sourced products, such as proprietary parts on which a supplier firm has Intellectual Property rights. Single Sourcing is a deliberate choice of one particular supplier over another. Single-sourced product parts are expensive because the manufacturer can dictate his prices. In addition to uncompetitive prices, there is also an element of risk involved: the production can get seriously disrupted when a supplier is unable to deliver the ordered product parts.

HOW

The Material Review Board, in which both Purchasers and (Design) Engineers participate, works out a Risk Mitigation Plan that stipulates in advance which alternative product parts from other suppliers are good enough to function as replacements. One of the ground rules of the Material Review Board (there is one Material Review Board for each Programme) is to avoid Single Sourcing.

Although there is a clear understanding between Purchasers and (Design) Engineers on the issue of Single Sourcing, the Purchasing department feels it necessary to keep reminding the (Design) Engineers: *To set off their technical blinkers and think only in terms of what is best for Firm A. For example: How is the choice of a particular product part going to affect the total costs of the Programme? Are there qualified alternative product parts from multiple suppliers?*

The Senior (Design) Engineer describes the decision making as follows: *If we have product parts from two suppliers, we leave the choice to Purchasing (i.e., which supplier to choose). But if we as (Design) Engineering have specific needs, then we will make the choice (i.e., which product part to use). As a rule, we try to find product parts that are tested, qualified, and cheaper. Basically, you don't want to develop something that is already on the market. But if you can't solve the problem then you contact a supplier, or more of them, and see if they can develop the item for you. But we only do it when all else fails.* The Purchasing Manager notes: *Sometimes there is nothing to choose between the suppliers, but then you have at least identified the potential risks at an early stage and can take steps to mitigate them.*

In practice, however, Single Sourcing is sometimes unavoidable. For example, in situations of the 'build-to-print' orders, or in situations where the compatibility of product parts is at stake.

The 'build-to-print' orders may contain proprietary parts that the supplier had developed to meet the specific requirements of the customer. The supplier firm then holds Intellectual Property rights for the use of proprietary parts.

The compatibility of product parts is a particularly acute problem when selecting product parts for electrical equipment systems (e.g., flight control systems, in-flight entertainment systems, etc.). If suppliers of the electrical equipment systems choose to use expensive product parts inside their products, then Firm A, as manufacturer of the outside electrical connections has no other choice but to use the same product parts as the equipment system suppliers do. This in practice means that the suppliers of electrical equipment systems determine the choice of two-thirds of product parts in the aircraft, whereas Firm A can choose only one-third.

The triadic relationship between the suppliers of electrical equipment systems, the customer of Firm A, and Firm A is a difficult one. Firm A may suggest to replace the current parts with cheaper alternatives of equal quality, but the decision to switch over to an alternative product is in the hands of Firm A's customer (who bears the costs of the product parts) and the electrical equipment system supplier.

The supplier of electrical equipment system usually argues that the product parts that are currently in use have been specifically qualified for that particular application, and are of high quality. The supplier of electrical equipment systems may appear to be prepared to substitute the expensive products with cheaper alternatives, but only on condition that either Firm A, or the customer of Firm A, pays for the qualification and testing of the alternative product parts.

WHY

Firm A strives to uphold its reputation of a cost effective and high-quality manufacturer in order to stay competitive. The policy of Single Sourcing avoidance is part of this strategy: its aim is to achieve competitive playing field in the purchasing of product parts.

BOX 4.11

REFLECTIVE COMMENT

The purchasing policy of Firm A is to avoid Single Sourcing because it leads to uncompetitive pricing. In contrast, the suppliers of electrical equipment systems defend their use of Single Sourcing on grounds that their products are of high quality, and have a qualification certification.

The literature supports both views. On the one hand there is concern about the uncontrolled costs and dependency, on the other hand, there is the appreciation of the improved product quality that long term relationships help achieve (Larson and Kulchitsky, 1998; Ulaga and Eggert, 2006).

Perhaps Purchasing departments should reconsider Point #4 of Deming's 14 Points for Management which states: "End the practice of awarding business on the basis of price tag. Instead, minimize total costs. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust" (Deming, 1986).

SALIENT ISSUE: **Single Sourcing and information and knowledge exchange.**

Affordability

WHAT

Affordability initiatives of Firm A are part of constant vigilance that Firm A exercises to find new ways to reduce the total Programme costs for the customer. In Firm A, these initiatives belong to the activities of the Affordability Committee in which Purchasers and (Design) Engineers participate. The two main cost reduction areas are COTS (commercial off-the-shelf) products and Product diversity.

HOW

The Affordability initiatives can be made mandatory by the customer. For example, the total costs of the product must be reduced annually. In such cases, the cost reduction measures are discussed in the weekly telecom meetings of the Affordability

Committee consisting of (Design) Engineering and Purchasing of Firm A and their counterparts from the customer's firm. In other cases, Affordability initiatives are a service that Firm A provides to the customer and through which the firm increases its reputation for costs efficiency. The Affordability initiatives are always a joint effort of Purchasing and (Design) Engineering.

COTS (commercial off-the-shelf) products

Firm A proposes COTS products to the customer as an alternative to proprietary parts. The Affordability initiatives start by bringing the customer and suppliers to the negotiation table. The Programme Director explains the process: *Based on our knowledge of the supplier market, we can suggest to our customers which proprietary parts in their design could be substituted with COTS parts, or which suppliers to choose for the development of the substitute parts. Once the customer agrees, our Purchasing department contacts the relevant suppliers. And what we see is that the suppliers are frequently prepared to cooperate and to invest in developing an alternative to the proprietary part.* A supplier's Sales Engineer acknowledges this when he says: *Participating in the Affordability initiatives raises our profile as an innovating firm.*

Once the customer has agreed to the proposal, Firm A can take the next step. Firm A invites all suppliers together, gives them the customer's product performance requirements, and requests them to develop a product alternative that is both qualified and can be used across diverse Programmes. The costs of qualification of the new product part are born either by the supplier, or by the customer.

Firm A can invite to the table suppliers that are already known to the customer, but it can also introduce a new supplier. The final decision, as to which of the suppliers' product design to choose is, however, always with the customer. The decision criteria are design quality, price, and the customer's past experience with the supplier.

Product diversity

Reducing product parts diversity is another type of Affordability initiative. In their proposal to the customer, Firm A can, for example, point out that: *If you use only one specific type of product part, rather than using three types of the same product part in your Programme, and if you select product parts from multiple suppliers, you can substantially reduce the Programme's total costs.*

WHY

Reducing the total costs of Programmes enhances the firm A's reputation for cost efficiency. The Affordability initiatives cost Firm A nothing in monetary terms because the initiatives are solely based on the internal knowledge of Purchasing (knowledge about the supplier market) and (Design) Engineering (knowledge about low cost design solutions). This combined knowledge has a negotiating value and gives Firm A the needed authority to launch the Affordability initiatives.

BOX 4.12

REFLECTIVE COMMENT

The experience of Firm A with Affordability initiatives suggests that competition and cooperation can coexist, and can lead to improved products. The knowledge about the supply markets and the knowledge about low cost engineering solutions enhance the negotiation position of Firm A, and confirm the firm's reputation for cost efficiency.

The role that Firm A adopts in the Affordability initiatives is reminiscent of 'tertius iungens', or 'third who joins' (Obstfeld, 2005). Tertius iungens is "a strategic behavioural orientation toward connecting people in one's own social network by either introducing disconnected individuals or facilitating new coordination between connected individuals" (Obstfeld, 2005: 102). Firm A displays the strategic behavioral orientation when it brings together the preferred suppliers and the customers of Firm A. The chief task of Tertius iungens is to act as a broker between parties and thereby facilitate the interaction of ideas.

SALIENT ISSUE: **The negotiating value of information and knowledge.**

4.2.3 Customer's Purchasers /Supplier's Sales Engineers dyad (CP/SSE)

The Purchasing department of Firm A and the suppliers' Sales Engineers are the front line of contact between Firm A and supplier firms. The information relationship between the two parties relate primarily to preferred supplier performance.

The supply base of Firm A consists of some 180 supplier firms of which approximately twenty firms are responsible for supplying 80 per cent of 150.000 product parts that Firm A needs for the manufacture of their advanced electrical distribution systems. These twenty firms are the so-called preferred, or strategic, suppliers.

Preferred suppliers performance

WHAT

Firm A selects its preferred suppliers not so much on grounds of the quality of their products, because as the Purchasing Manager puts it: *There are many firms that produce product parts of acceptable quality*. Firm A selects its preferred suppliers on their performance.

HOW

The Purchasing Manager of Firm A lists the following requirements (in no special order) that Firm A expects a preferred supplier to comply with:

- Supplier firm is a cost leader;
- Supplier firm is a global actor;
- Supplier firm provides advanced logistics solutions;

- Supplier firm is capable to qualify and design new product parts; and
- Supplier firm maintains a configuration management system.

The performance of preferred suppliers is evaluated for the efficiency of logistics processes. The Purchasing department of Firm A has two web-based systems at its disposal with which to undertake supplier assessments. One system monitors the volume and diversity of product parts that each supplier delivers to diverse Programmes. The other system, the so-called Supplier Relations Management System, evaluates suppliers' price competitiveness, product assortment, product quality, and performance in terms of (delay) delivery times. The ratings that Firm A gives to suppliers can be a starting point for discussions about how to bring the supplier to a higher level of performance.

The Purchasing Manager shows a record for one of the preferred supplier: *Here we see that in November 2010, Firm A received from this particular supplier 295 ordered items, of which 97 were delivered late, which means that 67% arrived on time. The average delay in delivery was 22 days. We share this information with the supplier, and together, we set up a plan for performance improvement.*

Sometimes Firm A and the preferred supplier cooperate in order to facilitate the logistics process. A Sales Engineer gives an example of a logistics solution that his firm co-developed with Firm A: *We have set up a Web Portal with Firm A. That means that we communicate in their language: they issue their orders using their own internal Part Number References (subsequently translated into the supplier Internal Numbers). It's an automated process and Firm A can be more efficient because of that. We take off the workload from their administrative organization.*

WHY

Prudent purchasing helps Firm A stay competitive. Suppliers have been known to vary their price policy per customer. Thus, prices of the same product part may differ not only from supplier to supplier, but also across Programmes. Having a comprehensive overview of supplier market enables Firm A to propose to the customer alternative combinations of product parts, and to allocate purchasing volumes in such a way as to benefit from supplier discounts.

WHY NOT

Interestingly, the list of requirements for preferred suppliers as provided by the Purchasing Manager of Firm A, does not specifically refer to knowledge exchange with suppliers. It is interesting because the Mission Statement of Firm A underlines the importance of knowledge exchange between Firm A and its suppliers:

> *Good relations with our suppliers strengthen our ability to solve the needs of our customers. The performance of our suppliers on quality, costs and on-time delivery is the key for the success of all of us. The integration of both our knowledge and technologies in product design are beneficial for all parties.*

By comparison, the interviews with suppliers' Sales Engineers revealed that they were well aware of the potential value that the exchange of knowledge could bring to customer/supplier relationships. For example, the element of knowledge exchange has been specifically mentioned in one Sales Engineer's definition of preferred supplier: *I am a preferred supplier, when the (Design) Engineers (of a customer firm) facing a new issue, call me first to see if I have a solution. That would be my definition. Besides being on the list of preferred suppliers, it is really a human attitude: 'I will call 'John' to double check if there is a good solution internally within his firm, if he could give me some direction." And when my firm cannot supply the product, I would suggest which other suppliers might be useful, and which labs would be able to support that kind of request.* The Sales Engineer, however, realizes that his definition only applies to his relationships with (Design) Engineers. But, he quickly adds that the definition could also apply to Purchasing. For example, in situations when the (Design) Engineer would request Purchasing to make inquiries with suppliers on the (Design) Engineer's behalf. The Sales Engineer however points out that such situations don't happen often: *Purchasers don't like to do that (making this kind of inquiry) because Purchasers know that the supplier's Sales Engineer would expect feedback from them, and Purchasers are aware that their contacts with the supplier's Sales Engineer need to be more comprehensive, so they prefer not to ask that kind of questions.* This observation is interesting because the incident described in Section 4.2.1 ("The Bill of Materials") relates precisely to this kind of situation. The Expert Manufacturing Engineer approached Purchasing with a request to contact suppliers, but only after he had developed the 'new' product part himself. Had he contacted Purchasing earlier, he would have learned that the product part already existed in the product assortment of a preferred supplier.

BOX 4.13

REFLECTIVE COMMENT

At present, Firm A seems to focus more on the performance rather than on the capabilities of their preferred suppliers. As a result, supplier development - from the perspective of Purchasing - means performance improvement only. However, supplier development is a two-sided coin. On the one side, developing supplier performance means reducing costs. On the other side, developing supplier capabilities means making technical adjustments in design and production processes by using supplier knowledge (Krause et al., 2007; Modi and Mabert, 2007; Schiele, 2006, 2010; Wagner and Krause, 2009). In contrast, supplier firms of Firm A prefer to see themselves as solution providers.

SALIENT ISSUE: **Preferred suppliers as a source of information and knowledge.**

4.3 **Salient Issues in the dyadic information relationships of Firm A.**

The Within-case Analysis of the three functional dyads found operating in Firm A has led to the identification of the following Salient Issues:

In the dyad of Suppliers' Sales Engineers and Customer's (Design) Engineers, SSE/CDE (Section 4.2.1):

- Information and knowledge exchange through social ties (Box 4.4);
- Knowledge properties of social ties (Box 4.5);
- Sole sourcing and information and knowledge exchange (Box 4.6);
- The role of trust in information and knowledge exchange (Box 4.7);
- The strength of social ties (Box 4.8);
- The exchange of information and knowledge as business courtship (Box 4.9); and
- The supplier's Sales Engineer as a social mediator between his/her firm and the customer's (Design) Engineers (Box 4.10).

In the dyad of Customer's Purchasers and Customer's (Design) Engineers, CP/CDE (Section 4.2.2):

- Single Sourcing and information and knowledge exchange (Box 4.11); and
- The negotiating value of knowledge (Box 4.12).

In the dyad of Customer's Purchasers and Supplier's Sales Engineers, CP/SSE (Section 4.2.3):

- Preferred suppliers as a source of information and knowledge (Box 4.13).

The Salient Issues are grounded in the evidence collected through interviews, field notes, documentation, and e-mail correspondence. In all, 15 informants participated, representing the functions of (Design) Engineering, Purchasing, and suppliers' Sales Engineering. The analysis has been guided by the Research Questions, and focused on the What's, the How's, and the Why's/Why not's of the dyadic information relationships. Table 4.4 gives a summary of the analysis.

The Salient Issues of Firm A serve as input for a Cross-case Analysis (Chapter 8).

Table 4.4 Firm A's dyads

Dyads	DYADIC INFORMATION RELATIONSHIPS OF FIRM A			
	WHAT	HOW	WHY/WHY NOT	Salient Issues
Suppliers' Sales Engineers/ Customer's (Design) Engineers Section 4.2.1	**Trade Studies:** comparative tests of product parts and product concepts on the market. **Hand tool development**: to make product part installation easier and less time consuming. The Chief (Design) Engineer approached a preferred supplier. **Integrated product teams:** (Design) Engineers & Purchasing of Firm A/ Sales Engineers and (Design) Engineers of supplier firm work together. **Identifying new technologies:** Firm A learns from supplier presentations. **The Bill of Materials (BOM):** The Expert Manufacturing Engineer develops a product part and asks Purchasing to find a supplier for its manufacture. **The 'sounding board':** Firm A advises customers on product specifications for the customer's new product concepts. **Visits to supplier manufacturing sites** by customer's (Design) Engineers	**Streamline** product part offerings. Suppliers provide fully functional product samples. Optimize design and production costs. Trade Studies are part of PDR (Preliminary Design Review). **Supplier's** Sales Engineer formed a team of (Design) Engineers from his firm. Team visits Firms A. New tool saves 15 minutes on assembly time. Can be handled with one hand. **Customizing** customer's product parts. Testing and qualifying product parts. **Firm A** and supplier firm jointly incorporate supplier new technology in the customer's product; discuss customer's requirements &manufacturability issues. **Purchasers** make inquiries. The product part is already in the assortment of a preferred supplier. **Validation** trials. Contacting suppliers to produce product samples to customer's specifications. Firm A performs the tests at cost price. There is no time limit. **Supplier's** Sales Engineer arranges the visit.	**Recommending** product parts and cost design solutions, with reasons for their rejection. Qualification of product parts. Trade studies not optimally used. The exchange of information is governed by interpersonal social relationships. **The Chief** (Design) Engineer knew that the supplier attended to this kind of inquiries. Supplier views the tool development as service. The firms must have related engineering knowledge. **Getting** lead time advantage over competitors by qualifying product parts that can be manufactured by only one supplier. **The supplier** and Firm A support each other, and complement each other's knowledge. deal with customer's questions together. **Firm A** is in a position to overview BOM's of diverse programmes. Not all supplier offerings are listed in the supplier catalogue. A learning opportunity for all parties involved. A potential business opportunity: orders in the future. **Learning** about supplier's products, and people behind them.	**Information and knowledge exchange through social ties (Box 4.4)** **Knowledge properties of social ties (Box 4.5)** **Sole sourcing and information and knowledge exchange (Box 4.6).** **The role of trust in information & knowledge exchange (Box 4.7).** **The strength of social ties (Box 4.8).** **The exchange of information & knowledge as business courtship (Box 4.9)** **Supplier's Sales Engineer as social mediator (Box 4.10).**
Customer' s Purchasers/ Customer's (Design) Engineers Section 4.2.2	**Product part selection & risk assessment:** Single Sourcing avoidance. proprietary parts. **Affordability**: reducing total Programme costs. Proposals to the customers to use COTS (commercial off-the-shelf) products.	**Selection** by Material Review Board, with participants from Purchasing and (Design) Engineering. Risk Mitigation Plan. Multiple sourcing strategies. **Asking** suppliers to develop alternatives to proprietary parts. Exploiting Firm A's knowledge of supply markets and low cost design solutions.	**Uphold** reputation of Firm A as cost effective manufacturer. Achieve competitive playing field for the purchasing of product parts. **Affordability** initiatives enhance the reputation of Firm A for cost efficiency.	**Single Sourcing and information and knowledge exchange (Box 4.11)** **The negotiating value of knowledge (Box 4.12).**
Customer's Purchasers/ Suppliers' Sales Engineers Section 4.2.3	**Preferred suppliers performance:** supplier performance is the chief criterion.	**Web-based** tools for monitoring supplier performance. Supplier development. Web Portals co-developed with preferred suppliers.	**Prudent** purchasing helps Firm A to stay competitive. Requirements for preferred suppliers don't specifically mention knowledge exchange. In contrast, preferred suppliers see themselves as solution providers.	**Preferred suppliers as a source of information and knowledge (Box 4.13).**

Chapter 5: **The Within-case Analysis of Firm B**

5. Introduction

Firm B is a tier-two supplier of mirror technology in the automotive industry. The subject for the present case study was suggested by the Manager Research of Firm B. The project, in which Firm B acts as customer, concerns the development of new housing/casing for two models of an extant product. The original housing was made of plastic, whereas the new housing is made of steel. The reasons for the material switchover were threefold: to achieve costs savings, to increase the housing stiffness that could not be realized with plastics, and to reduce the number of parts in the product.

The case study informants came from the functional areas of (Design) Engineering (7) and Purchasing (1) of Firm B, and from the Firm B's supplier, in the person of Director Sales & Engineering (1), hereafter referred to as Supplier's Director. The figures in brackets give the number of participants.

5 The analysis of Firm B proceeds in two steps shown in Table 5.1. Step 1 describes the external information relationship arising from the tier-two status of Firm B (Section 5.1), and the external information relationships arising from market trends analyses, including the Firm B's effort to streamline the information sources (Section 5.1.1). Step 1 concludes with the researcher's Reflective Comments (Boxes 5.1 and 5.2). Step 2 focuses on the micro-social level of Firm B represented by the interpersonal dyadic information relationships between the individuals working in three functional areas. Table 4.1 shows and Figure 4.1 illustrates the three dyads under study, namely:

- Supplier's Director/Customer's (Design) Engineers (Section 5.2.1)
- Customer's Purchaser/ Customer's (Design) Engineers (Section 5.2.2)
- Customer's Purchaser/ Supplier's Director (Section 5.2.3)

The analysis is guided by the Research Questions and examines the What's, the How's, and the Why's/Why not's of these dyadic information relationships. Table 5.3 provides a summary.

The analysis of each dyad concludes with the identification of Salient Issues (Boxes 5.3 – 5.7), based on the researcher's Reflective Comments about the found evidence. In turn, the Salient Issues (last column in Table 5.3), serve as input for the Cross-case Analysis in Chapter 8.

Table 5.1: Steps of analysis of Firm B

Step 1	External information relationships of the firm.	External information relationships of Firm B arising from tier-two status of Firm B (Section 5.1); Information relationships arising from market trends analyses, including the Firm B' effort to streamline the information sources. (Section 5.1.1)	**Outcome:** Reflective Comments made by the researcher on external information relationships. (Boxes 5.1 and 5.2)
Step 2	Micro-social level information relationships of the firm.	Information relationships of the three dyads: Supplier's Director/ Customer's (Design) Engineers (Section 5.2.1); Customer's Purchaser / Customer's (Design) Engineering (Section 5.2.2); Customer's Purchaser/ Supplier's Director (Section 5.2.3)	**Outcome:** Salient Issues in information relationships in each dyad, supported by the researcher's Reflective Comments. (Boxes 5.3 – 5.7).

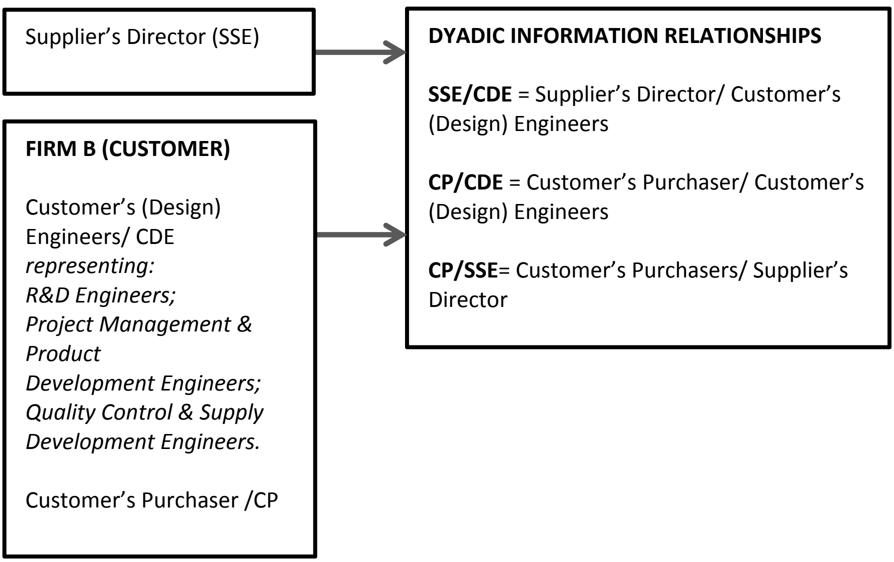

Figure 5.1 Schema of the case study of Firm B.

5.1 External information relationships arising from the tier-two supplier status of firm B

Firm B is currently in the third stage of its life cycle. The firm started in the 1930's as a successful family owned machine shop, was sold in the 1990's to a large US automotive group, and after twenty years, Firm B was sold again to a Private Equity Company. Firm B has production and assembly facilities in Mexico, China, and Ireland. The case study took place at the Headquarters of Firm B, which houses Management, Sales, R&D, Product Development, and Quality Control.

Originally, Firm B was a tier-one Supplier that produced sub-assembly systems and delivered them directly to car manufacturers. During the period 1969-1993, Firm B developed and introduced its own new products (supported by patents), and successfully participated in NPD of the German car manufacturer BMW, and other OEMs (original equipment manufacturers). The sub-assembly systems of Firm B were used in luxury cars; they were niche products.

The fact that Firm B has slipped down the tier hierarchy of supply chain can be ascribed to two factors. One factor is the commodification of special features in cars: what has once been a luxury accessory for expensive cars is now available in every car. The other factor is the restructuring of the automotive supply chain that began when car manufacturers started to outsource the production of sub-assemblies to suppliers. The practice of outsourcing, coupled with the increased manufacturing responsibility that suppliers acquired in consequence, had led to a wave of acquisitions and mergers that had swept the automotive supply chain in the 1990's. The outcome of this consolidation process was an emergence of a new type of tier-one supplier. The literature (Sturgeon, Van Biesebroeck, and Gereff, 2008; Veloso and Kumar, 2002) describes the new tier-one suppliers as 'mega suppliers', or conglomerates with a global presence. The mega suppliers act as system developers, or system integrators, for the OEMs (original equipment manufacturers).

The supply base of Firm B consists of 70 worldwide suppliers. Of these, 10 supplier firms are considered by Firm B to be 'preferred' suppliers. It is worth noting that the term 'preferred supplier' is in Firm B used only by the Purchasers and the Quality Control Engineer. The (Design) Engineers use the term 'suppliers of preferred technologies'.

Firm B has a 'preferred' supplier for each of the ten categories of product parts that are integral to the functioning of the products of Firm B. These suppliers are firms with which Firm B maintains a long standing relationship. Often, the preferred supplier is also the biggest volume supplier within a product parts category. Preferred suppliers have been screened by Purchasing of Firm B for their financial strength and technical capabilities. Firm B regularly invites preferred suppliers to participate in the firm's NPD projects.

The driving force behind external information relationships of Firm B is the wish to resurrect the direct contacts that Firm B used to have with OEMs when it enjoyed the status of tier-one supplier. The inter-firm relationships of Firm B are therefore geared towards demonstrating the (design) engineering capability of Firm B, and to by-pass (or to co-operate with), the mega-suppliers in the process. Several case study informants have sketched a scenario, described as a *push-pull strategy*, whereby the car manufacturer would specifically request the mega-supplier to include in their systems products of Firm B because of the superior quality of Firm B's engineering. In such case, the OEM would issue a directive-buy.

The Manager Engineering Projects argues that Firm B can compete with mega-suppliers not only in terms of engineering quality, but also in terms of *robustness of the design process (i.e., the informed and documented decisions that lie behind a systematic six stage-gate design process controlled by the Decision Gate Committee).*

Firm B wishes to restore direct relationships with OEMs because it wants to have an effective exchange of information: to learn at first-hand what the needs and plans of the customer are, so as to be able to anticipate the future trends. With its continuous strong tradition in patents, Firm B feels confident that they can offer innovative products to OEMs. Firm B has learned through experience that second hand information from mega suppliers about the needs of the ultimate customer may not always be reliable, as the following incident illustrates.

The Senior R&D Engineer recounts the event of a large order from a firm (that since then ceased to exist) for a medium-sized mirror instrument to be used in SUVs (Sports Utility Vehicles) of General Motors. *The original order was for 2 million products, and that is for us a big enough volume to develop something special for the customer. In the end, the order was only for 1 million, and after two years, the final customer (General Motors) did not want to purchase the product any more. The product was made according to the received specifications, but it turned out that it did not meet the needs of the end customer. In my view, this incident was a turning point for our firm. From then on we decided not only to talk to mega-suppliers but to their customers as well.*

When questioned about the reaction of mega-suppliers to this new approach of Firm B, the Senior R&D Engineer replied: *Well, ten years ago, it was certainly 'not done' that a tier-two supplier would sit at one table with an OEM, and the mega-suppliers did not like it. But the OEMs are aware that our instrument is a very important component which to a large extent determines the functionality of the end product, and therefore, they want to talk to us as well as to the mega-suppliers*. However, the Manager Engineering Projects warns that in the global automotive industry there are only very few OEM's that put quality above price. These OEM's set high product specifications hurdles. *Once you pass the hurdle, and meet the product specifications, then the price-fight begins, often down to the tenth of a cent.*

BOX 5.1

REFLECTIVE COMMENT

The quandary that Firm B finds itself in lies in the simple fact that the customers of Firm B are also the major competitors of Firm B. The new tier-one suppliers, the mega-suppliers (3-4 worldwide conglomerates) are vertically integrated and can, therefore, often produce the sub-assembly products that Firm B makes. In a positive scenario, the mega-suppliers may decide to incorporate the products of Firm B in the systems that they supply directly to OEMs.

The dependence of Firm B on mega suppliers is all the more troublesome considering the long patent tradition of Firm B. The focus of external information relationships of Firm B is to strengthen the ties with OEM's. Firm B sees itself first as a market leader and only second as a supplier. The strategy of Firm B is consistent with the research by Wynstra et al. (2010) whose research suggests that the position in the supply chain has no direct effect on innovation strategy. Thus, in persevering in their innovation-oriented strategy, it should be possible for Firm B to regain their presence in the OEM's product development.

5.1.1 Information relationships arising from market trends analyses

In order to identify the needs of the market, the R&D department of Firm B adapted the method of AHP (Analytic Hierarchy Process) surveys, developed by Saaty (1990), for use in the Firm B's product portfolio. Firm B deploys the AHP surveys to collect and prioritise customers' requirements. The AHP hierarchies consist of quality dimensions pertaining to product features, product functions, and electrical & mechanical performance. The AHP surveys are carried out whenever Firm B is considering starting up a product development project, that is, at the stage of 'Decision Gate O'. Each project, however, needs first to be approved by the Decision Gate Committee (DGC). The DGC meets monthly, and its task is to decide whether the proposed product idea fits within the strategy of Firm B.

At the stage of 'Decision Gate O', there is as yet no specific customer for Firm B. The AHP survey is a way of canvassing the views of leading players in the automotive industry. In finding contact persons in OEMs for an AHP interview, Firm B can rely on the relationships that the Manager Engineering Projects and the Sales department had built up with OEMs throughout the years. Although the interviews last between 90-120 minutes, most OEMs are prepared to set the time aside for the interviews because they recognize the value of such exchange of information. The Manager Engineering Projects puts the willingness of OEM's to take part in the AHP interviews at 80 per cent.

The Senior R&D Engineer describes the AHP survey as follows: *The AHP surveys are now a standard tool, almost a routine, to detect market trends. It saves us a lot of time.*

Usually we (R&D and Sales) visit customers (this could be as many as 16 firms per one AHP round, both OEMs and mega-suppliers), and talk there to Head of (Design) Engineering and someone from Purchasing; that's a good combination. It's important to talk to decision makers, so that the information exchanged is not later overruled. We ask (Design) Engineering and Purchasing to list their requirements and wishes, using the AHP quality dimensions, and to give the dimensions which they select a priority rating. In the end you get a list of some 20 quality dimensions coming from a wide range of customers. You know what the customers are interested in, and you also learn which of the quality dimensions are important to them. The list is, of course, longer but the quality dimensions that you were already aware of are distilled out. The next time we visit the customers, we have a working prototype with us, and often, (Design) Engineers from our Product Development (PD) accompany us. If the customer likes the prototype, and we have a good feeling about it, then the AHP survey is followed up by QFD (Quality Function Deployment) whereby the customer requirements are translated into technical functions. From then on PD Engineers are fully involved in the project. In fact, starting with a second product sketch, PD (Product Development) Engineers are already looking over our shoulder. They need to feel confident that the product can be mass produced. You have to convince them as well as the customer.

However, there are voices in Firm B that caution against drawing rash conclusions from the AHP findings. For example, the Purchasing Manager warns that: *What you need to bear in mind is to whom you are putting the question. For Purchasing, the costs will always be of paramount interest, whereas Engineering will be more concerned about product features and functionality. So you have to balance the findings against each other.* The Manager Engineering Projects concurs with this view: *It is important to involve both (Design) Engineering and Purchasing so that you get a wide enough range of answers in order to discern a trend.* The Manager Engineering Projects observes further that: *The AHP survey has two functions one practical, and one tactical. The practical function concerns how you spend your money. There is only that much money that you can spend on a project. Therefore, it is important that you are as clear as you can be about the direction of customer needs. The tactical function concerns the persuasive power of a structured approach. Design is all about making choices, reaching compromises; there is no ultimate design. If I say to someone that I have a brilliant idea, that I am sure it would be a success, and that I need five million Euros to finance the project, then it is unlikely that anyone would believe me. If, however, I can produce documents showing that I have done market research, and that the findings support the product idea (even if the evidence is all rubbish!) then the research process alone represents value that evokes trust. With the AHP surveys we can demonstrate that we talked to customers, analysed the responses, and refined the goal and scope of the proposed design project.* In other words, the AHP surveys are presented here as a negotiating tool.

Streamlining the information sources

The AHP surveys are not the only approach that enables Firm B to collect information about market trends and technology developments. Table 5.2 gives an overview of the external and internal information sources that Firm B uses, the methods of exchanging information, and the application use.

Table 5.2: External and internal information sources of Firm B

Information sources	Methods of exchanging information	Application use
Customers	AHP (Analytic Hierarchy Process) surveys	Customers rate their product requirements against AHP quality dimension criteria.
	QFD (Quality Function Deployment)	Translating customer requirement into technical function.
	Sales department of Firm B Trade shows	Signalling the needs of customers. Arranging meetings with customers
Competitors	Subscription to patent databases by R&D of Firm B.	Scanning of patents and patent activity in the technology categories relevant to Firm B.
	Reverse engineering (i.e., dismantling) of competitors' products by R&D of Firm B.	Analysis of product parts, materials, costs, and the working principle of products.
	Trade shows	Collecting product samples and brochures.
Morphological map	Method developed by R&D department of Firm B.	Compilation of manufacturing solutions applicable to products of Firm B.

A very special information source of Firm B is the Morphological Map that the R&D department has developed during the past 15 years. The Morphological Map is a compilation of manufacturing solutions (ranging from cheap solutions to expensive ones) for each of the 12 product functions that can be found in the products of Firm B. The solutions data, displayed visually in a wall-sized matrix, have either been applied by Firm B in the past, or were found in patents, or in the literature. For most of the manufacturing solutions there is a back-up collection of product samples. The online version of the Morphological Map can be accessed and searched by the Engineers of R&D and Product Development.

BOX 5.1

REFLECTIVE COMMENT

For Firm B, the purpose of collecting and streamlining the external and internal information is twofold. On the one hand, Firm B seeks to discover the views of the customers' Purchasing and (Design) Engineering about future developments in the car industry. On the other hand, the process of information seeking and its documented results are used as tools with which to demonstrate to the customer the thoroughness and completeness of the Firm B's approach to NPD.

5.2 **Micro-social level information relationships of Firm B**

The previous sections (5.1-5.1.1) described the external information relationships of Firm B. The next sections analyse the information relationships of Firm B at the micro-social level, that is, within the dyadic relationships. The informants came from (Design) Engineering (7) and Purchasing (1) of Firm B, and from the functional area of Engineering/Sales of the Firm B's supplier, in the person of the supplier firm's Director. The dyads found operating in Firm B are:

- Supplier's Director and Customer's (Design) Engineers (Section 5.2.1)
- Customer's Purchaser and Customer's (Design) Engineers (Section 5.2.2)
- Customer's Purchaser and Supplier's Director (Section 5.2.3)

The analysis of the dyads follows the three Research Questions and addresses the What's, the How's, and the Why's/Why not's of the dyadic information relationships. Table 5.3 provides a summary. The analysis of each dyad concludes with the identification of Salient Issues in the dyads' information relationships (last column in Table 5.3), supported by the researcher's Reflective Comments on the evidence found. The Salient Issues are the input for the Cross-case Analysis (Chapter 8).

Given the fact that the case evidence is in places quite detailed, the text works with graphic symbols in order to ensure legibility. Each time a new facet, or stage, in the dyadic information relationship is introduced, the text paragraph is indented, and marked with two underlined asterisks (**).

5.2.1 Supplier's Director / Customer's (Design) Engineers dyad (SSE/CDE), with three sub-levels

For the present case study, the informants representing the function of (Design) Engineering came from the following departments:

- Research & Development (R&D),
- Project Management & Product Development (PM & PD),
- Quality Control & Supplier Development Engineering.(QC-SD)

All three departments maintain their own contacts with suppliers. Therefore, the information relationships that the individuals working in these departments have with supplier firms represent three sub-levels of the Supplier's Director/ Customer's (Design) Engineering dyad. The next section will examine each of the sub-levels separately in order to provide a fine grained analysis of the information relationships that (Design) Engineers of different professional backgrounds maintain with the representatives of supplier firms. The information relationships are analysed against the background of the development of a new (steel) housing/casing for two models of an extant product.

Sub-level Supplier's Director/ R&D Engineers

WHAT

* * Exploring technology options. The information and knowledge exchange between R&D Engineers and suppliers is limited to the FFE of NPD projects in which R&D Engineers explore the use and applications of production technologies and materials that are new to R&D. The Manager Research describes the first stages of information exchange as follows: *First, I need to know whether the application I am thinking of is at all possible. When a suitable supplier is found, the second stage of information exchange involves Purchasing that checks the suppliers' competitive standing in that particular market.* The Senior R&D Engineer points out that in the areas of technology in which Firm B has had long experience (e.g., the thirty-year's experience with plastic materials), there is little that Firm B can learn from suppliers. On the contrary, the level of suppliers' knowledge has actually deteriorated: *In the past, suppliers of plastics were specialists who knew the properties as well as the applications of their products. Often, they had their own research facilities. So when you purchased a product, you purchased with it a piece of knowledge as well. But that's all gone. Nowadays, plastics are simply commodities to be sold. What we need to know in our applications is how plastics behave over time when subjected to mechanical stress; we need information about surface resistance and wear and tear conditions, and the suppliers don't have that kind of data anymore.*

** The development of a new housing/casing for an extant product part involved switching over from plastics to metals, and Firm B decided to seek outside advice. A hired engineering bureau investigated metal forming technologies, and advised the technology of deep drawn metal stamping. Firm B had some experience with metal stamping from previous projects (a central shaft component that was made of steel, with symmetrical shape). However, the manufacturing process of deep drawn stamped housing made of steel was new for Firm B, and the reliance on supplier knowledge was therefore considerable.

** Supplier contribution. The Senior R&D Engineer puts the contribution of the supplier firm at 90 per cent. In contrast, the Manager Engineering Projects holds a more nuanced view of the contributory value of suppliers: *We have 4-5 basic technologies that we use in our products, and we have applied these technologies through three, and in some cases through six project life cycles. What I mean by a cycle is a project of seven years which includes the ideation, production, release, use, and the discontinuation of a product. When you have been through such projects several times you have exchanged a lot of information with suppliers. Even in the case of precision stamping technology we have had some 15 years of experience. But in this particular case, the shape of housing was quite complex and that required an influx of new technology. What we see is that as technologies mature, we accumulate a lot of experience and knowledge. It is only when we are confronted with a new technology that we need an information and knowledge input from suppliers.*

In reply to a question whether there were situations where suppliers would bring new technologies to the attention of Firm B, the Manager Engineering Projects clarified the matter further, saying: *No they don't. What happens is that the supplier gets from us a technical drawing with a concrete design proposal, and we ask the supplier firm whether they can manufacture the product, or come with any proposals. Next time, we come to the same supplier with a technical drawing of another product. The supplier firm knows by then the technical functions of our products, and says: "You are always looking for materials with optimal stiffness, or a low friction coefficient, don't you? I have just seen a new material combination; wouldn't that be something for you?" And then we say: "Yes, that's a good idea", and that new material is then the supplier's input.*

<u>HOW</u>

<u>**</u> Supplier search and trade shows. Once the choice for deep drawn stamping technology has been made, the search for a supplier could start, involving all three Engineering departments and the department of Purchasing. Interestingly, the case study informants from Firm B were hard put to recall exactly when the current supplier of metal stamping came into picture. They all remembered that the supplier search, carried out world-wide, was a long one, and generally unsuccessful. Most of the stamping firms contacted said that deep drawn stampings of such complex product forms as Firm B had in mind were not possible. One or two firms were willing to have a go, but their prices were not acceptable for Firm B that had started the project with an objective to achieve cost savings. The Head of Product Development comments: *Actually it was quite surprising to see that, even with the Internet which makes a world-wide search easy, there were only very few firms that could do this kind of work.* According to the Supplier firm's Director, the initial contacts between his firm and Firm B stem from a meeting at a trade show. The Director, who is always present during trade shows, got talking to a (Design) Engineer from Firm B. The (Design) Engineer saw that the deep drawn stamped product parts that the supplier firm had on exhibit were of a similar shape as the housing/casing part that Firm B had in mind. Moreover, the (Design) Engineer learned that the supplier firm designed its own tooling, and was therefore able to customize the tooling to the requirements of Firm B. As it later turned out, the (Design) Engineer who visited the trade show did not actually work at the Product Development (PD) department of Firm B, but at the model making shop, but he was nonetheless aware of the on-going supplier search.

A PD Engineer comments: *The communication lines in our firm are short. It is not that one department wouldn't know what the other is doing. That's what makes the information exchange (because that's what it's all about) very easy. Everyone has his own ideas, his own contacts and news over a certain area of work. Every two weeks we have a departmental meeting where such issues can be discussed.*

<u>**</u> Steps in the conceptual design phase. The work of R&D Engineers formally ends with the conceptual design, and a Design Review meeting. In that meeting the design concept, mostly in the form of a CAD model, is handed over to Product

Development, thus marking the beginning of the embodiment design and detail design phase. Informally, the exchange of information, however, continues. The PD Engineer explains the interaction: *It certainly isn't the case that R&D would 'throw the design concept over the wall' to us. They involve us in the concept design. The conceptual thinking has become part of our work as well. They don't have the capacity to do it alone.* The exchange of information between R&D Engineers and PD Engineers concerns the (mass) manufacturability of products, and leads to continuous updating of the product concept. The new insights about product manufacturability are gained, for example, by dismantling of competitors' products, the so-called reverse engineering. All manufacturing solutions, often with product samples, are recorded in the Morphological Map which the R&D Engineers keep up to date and which can be accessed online. The phase of conceptual design development and the process of selecting the ultimate design concept belong to what Firm B refers to as the 'PRO-launch' process, where PRO stands for "Profitable, Reliable, On-time". It is a period between Gate 0 and Gate 2 of the six-gate design process controlled by the Decision Gate Committee (DGC). The Manager Engineering Projects describes the PRO-launch process as a '*reality check*' which R&D, Sales and PD Engineering carry out together in order to establish: *Is the product technically and commercially feasible? Does the Decision Gate Committee (DGC) agree that this product fits in the strategy of Firm B?*

<u>WHY</u>

<u>**</u> Adopting new manufacturing technology. The decision of Firm B to substitute plastics for steel in the new housing for two models of an extant product part represented a new direction for Firm B. The material switchover involved the adoption of new manufacturing technology. The reasons for this new direction were threefold: to achieve costs savings, to increase the housing stiffness that could not be realized with plastics, and to reduce the number of parts in the product from 30 to 20 (*Each product part is in itself a chance for a defect/mistake to occur.*).

BOX 5.3

REFLECTIVE COMMENT

The CAD models and the Morphological Map, the outcome of R&D work, facilitate the exchange of information and knowledge between R&D Engineers and PD Engineers. The Morphological Map is the Firm B's way of making tacit knowledge explicit (i.e., capturing manufacturing solutions learned through the experience in past projects to be reused in the future). Reverse engineering is another way of accessing tacit knowledge. Both the Morphological Map and CAD models are physical objects which serve as boundary objects (Carlile, 2002, 2004) because they enable communication and the exchange of knowledge across the boundaries of the diverse functions and disciplines involved in NPD.

(continued on next page)

BOX 5.3

REFLECTIVE COMMENT (cont.)
The research on team cognition by Stompff (2012: 193) found that when members of multidisciplinary teams interacted with tangible objects, it stimulated and prompted thinking and resulted in noticing unknown problems, or in devising new solutions. Since the (sensory) experiences of team members were fairly comparable, the tangible objects were instrumental in sparking discussions among diverse disciplines which otherwise would have difficulty in understanding each other.

SALIENT ISSUE: **Physical objects are information bearers during conceptual design stage.**

WHAT

***** Manufacturability issues. The main concern with the stamped steel housing was the complex shape of the product. The previous experience with stamping, the central shaft component, involved a simple shape of tubing. By contrast, the new housing required deep drawn stamping. The Head of Product Development explains the problem: *Some parts of the housing required forming that exceeded the conventional metal forming limit. Therefore, we have carried out a series of tests on these product parts, together with the supplier, to explore the manufacturing possibilities.* The PD Engineer adds: *In fact, we are continually challenging suppliers. Our products are never easy for them. That's what they tell us. We are always pushing the envelope to extend the limits of current practice.*

The embodiment and detail design phases of product development represent areas in which the exchange of information and knowledge between suppliers and PD Engineers has the greatest impact. In this phase, PD Engineers translate the design concept into product specifications that in their turn affect the manufacturing phase of the product. In other words, whereas PD Engineers determine the functions of the product, the supplier determines how these functions can best be manufactured.

** Prototypes & risk avoidance. The Manager Engineering Projects stresses that when the results of FMEA (Failure Mode and Effects Analysis) tests show that a dimension of a particular product part is *mission critical*, then Firm B needs to take extra precautions: *We are especially careful about checking out the suppliers' references. Has the supplier firm done this type of work before, and how often? The supplier firm does not need to have the necessary certifications, but must be able to demonstrate on the examples of past products that the firm can perform and control the manufacturing process.* Firm B can, as precaution, request the supplier to make prototypes, but that, as the Manager Engineering Projects points out, requires extra funding: *Since a proper simulation is not possible, the Decision Gate Committee needs to approve a special budget for prototypes and a small preproduction series of the product.*

It is my job to convince them that if they wish to proceed with the project, such advanced investment is justified. The Supplier firm's Director has this to say about the costs of prototyping: *We are not interested in making profits from prototypes. The prototypes are there to get the project as a whole. So if the prototypes are small, we make them free of charge. That way we avoid losing time by having to involve Purchasing, and we get the design team happy. But sometimes the prototypes are too big, and they are a financial risk for us, and we have to make an agreement.*

HOW

* * Meetings between PD Engineers and suppliers. The frequency of contact is high, particularly at the beginning of the project. When the supplier's tooling is being designed and trial tests run, there are weekly contacts between PD Engineers and the supplier firm. The PD Engineers themselves have fortnightly meetings in which they discuss the project's progress. The contacts with the supplier firm are mostly one-to-one: the PD Engineers know their counterparts within the supplier firm. Due to geographical proximity, the contacts are not limited to e-mails and phone-calls but include regular visits as well. The Supplier's Director notes: *We are looking for an efficient exchange of knowledge. In general, we prefer to go to the customer, because that's where the problem is, and where the knowledge about the problem is as well. If we make an appointment at our site, then the customer starts to be efficient, and sends just one or two guys to us, and that's mostly not enough. That way you cannot get enough people to think about the idea simultaneously. And you are also depending on someone who is not a specialist to bring the information back, and then there is always some information loss, and design alternatives may get lost as well.* The Supplier's Director describes how his first meeting with a customer usually looks like*: We like to go back to the basics. Mostly we are not involved in the early stages of product development; most of the time the development has moved on. That means that choices have been made, and the development has already taken a certain direction. So we try to go back a little bit and ask: "What is your intention? What did you mean by that choice?" And most of the time we discover (that's why we do it) that the choices were made because the customers lacked knowledge. They didn't know any other way, and we tell them that there are other possibilities, that things can be done differently. But, you have to bear in mind that sometimes the customer does not like to go back on his decisions (or there is no time), so you have to be careful to suggest that.*

****** Technical drawings. The process of embodiment and detail design starts with converting the 3D model that PD Engineers receive from R&D Engineers into a 2D drawing in order to be able to lay down precise technical specifications, and to establish allowable tolerances (i.e., the accuracy with which the product is to be made). Thus, the technical drawing becomes the main means of communication between PD Engineers and the supplier. The exchange of information and knowledge between PD Engineers and suppliers concerns two issues. Firstly, the product dimensions and tolerances as indicated in the drawings of PD Engineers. Secondly, the supplier's standpoint concerning the manufacturability and manufacturing costs.

A PD Engineer sums up the exchange of information and knowledge as follows: *We hear from suppliers that one in twenty dimensions in the drawings, or perhaps even more, that the tolerances in the drawing are not 'process capable', meaning that some modifications need to be made before the production process can start. Of course, the tooling is the supplier's own design, and we don't have any influence over it. The supplier can only tell us what the tooling can or cannot do. And then you often get a dimensioning discussion.* The Supplier's Director offers the following explanation: *The thing is that the information in the drawings is not sufficient. Never. It is a theory that you can translate all functional elements into a technical drawing. You can never highlight your thoughts sufficiently enough: what things in the drawing are important, and what is less important, and what the product functions and requirements are. That's the reason why I insist on talking to the designer. I need to know what the requirements are. A drawing alone is not enough.* As the exchange of information and knowledge between PD Engineers and the supplier intensifies, the accuracy and reliability of drawings increase. The supplier firm gains more insight into the product's intended functions, and PD Engineers learn more about the capabilities of the supplier's tooling. The Head of Product Development describes the gradual increase in accuracy and reliability of drawings thus: *You want to keep close tolerances specified in the technical drawing, and the first trial tests show that the tolerances are not possible. At that stage, your drawings are only about 50% reliable. Once the tooling has been designed and becomes operational, and you can produce first samples from this tooling, then the reliability of your drawings goes up to 80%. Gradually, the reliability of drawings becomes 100%, and at that stage the product can be released for production. There are supplier firms that take drawings as read. They think that if they meet the requirements set in the drawings that their work is done. But there are also supplier firms that enjoy manufacturing complex products: the more complex the better. They inquire about the exact function of the product part so that they don't need to perform unnecessary operations, and nor need we.*

<u>**</u> Negotiating product tolerances and dimensions. Resolving the different viewpoints that PD Engineers and the supplier firm have on product tolerances and dimensions occurs through negotiation. The PD Engineers wish to maintain close tolerances, the supplier suggests alternatives. Both parties are aware that when they allow some variations from the given dimensions, they may reduce production costs. The PD Engineer comments: *You cannot always work with a large tolerance. And there is, as far as I know, no simulation software for this kind of products. So it is a process between us and the supplier. And that's what makes this particular supplier firm attractive: they enjoy the challenge; they like to have an opportunity to tackle new problems. And if something cannot be done, they come with good arguments. They consult and deliberate with us.*

Another PD Engineer recounts one such consultation: *You then start doing your own tolerance tests. And you see that if the cam height does not stay within a certain tolerance, then the corner of the housing will fall outside the specifications. You discuss it with the supplier, and they carry out tests. It then turns out that because of the material thickness and piled mass of material, it cannot be done. Then we have to look whether we could not make other tolerances in the housing tighter, so as to compensate for a larger tolerance in the cam height.*

The Head of Product Development concurs: *That's what we did in this particular project, and along the way, we found that the modifications actually improved the manufacturability of the product. While developing, you discover new possibilities.*

******** Monitoring costs. The information relationship between the PD Engineers and the suppliers can also take the form of VAVE (Value analysis, Value Engineering) in which the customer and supplier firm jointly evaluate and assess the costs and function of all product components, and look for possible improvements. The PD Engineer reflects: *You don't know how flexible the supplier's manufacturing process is. To design a product in such a way that it is easier to manufacture can cut back the costs of the product considerably. For example, a small change in material may result in two cents savings of which we get only one cent.* Another PD Engineer agrees*: Improving the manufacturing process increases both the supplier's productivity and the product quality. And we benefit from the constant manufacturing performance. In the automotive industry the suppliers are required to come with costs reductions every two years. That means that their output must get higher than they had planned originally. Once the production gets under way, it is not difficult to see which parts of the production process can be improved. If you can increase your hourly production by 10%, than the required 2% reduction is not so much because that you had earned many times over.*

WHY

** Supplier selection. The Manager Engineering Projects offers his perspective on the information relationship between Firm B and the supplier when he notes: *There are two aspects. One: the supplier understands what we need and is prepared to apply the latest technology to our design proposal. When we give our technical drawings to the supplier, they are for 80 per cent free of errors or omissions. What is then needed is the last fine tuning; the supplier then brings in the latest specialist knowledge that we do not have. The second aspect concerns how well we can communicate with the supplier. It's not just communicating about the product, but also communicating about validation and verification methodologies and quality assurance. Do they know the shipping conditions? Do they use the same design engineering software? You need to clarify all this before you enter into a relationship with the supplier. It is quite complex and often culture-related. However, what you see in the global market of the automotive industry is that the most important factor is the price. The supplier with the lowest price gets the order.*

In the case of the supplier of the stamped steel housing, the PD Engineers appreciated the fact that the exchange of information and knowledge extended beyond the duration of the project. The PD Engineer gives an example: *For our current project on a low-cost product we needed a prototype of a spring component. Eventually, we found a supplier firm (Suppliers are usually not interested in making just a single prototype for you if there is no prospect of a whole project.), but the delivery time was four weeks. And then our R&D Engineer suggested that perhaps the supplier firm of steel housing might be able to help. Their website did not say that they also made that kind of products. However, when we telephoned, the Director asked to have our 3D file sent, and said, that because we were such good customers, he would have the component ready for us in two weeks.*

__** Preferred Suppliers versus Single Sourcing**.** The selection of suppliers is the task of the Sourcing Committee in which (Design) Engineering and Purchasing participate. The supplier of steel deep drawn stamped housing is a single source and a preferred supplier for Firm B. The distinction between the status of a 'preferred supplier' and that of a 'single source supplier' is not always clear. The Head of Product Development states: *We start each project with the objective of finding 4-5 suppliers, request quotations, and discuss the supplier selection in the Sourcing Committee (using an assessment checklist made by Purchasing). For Engineering, it is important to know whether the suppliers have the necessary manufacturing capabilities. Suppliers can send in wonderful quotations, but can they actually make the product? For that to find out you often need to have face-to-face contact with the supplier, so that they understand exactly what we need. Doing this with four or five suppliers costs a lot of time. But we have done it often with two suppliers. Of course, if you are looking for a standard product part, then you can always find a second or a third supplier. But for highly specialized products, such as deep drawn stamped product parts, that require expensive tooling, the option of dual or multiple sourcing is not always possible. The tooling is owned by Firm B, so that should the current supplier go out of business, we can move the tooling to another supplier. And, of course, you need to go twice through the product release procedure.* The PD Engineer notes: *Once the product part is made, you can show it to other potential suppliers, by way of proof, that the product part can really be manufactured. Showing the actual product has more effect than when you just show a technical drawing. And there is always a professional pride of supplier firms: 'if the other firm could make it, so can we!' So yes, Single Sourcing makes you vulnerable, but at least you know that the manufacturing is possible. Looking at our Purchasing, you see that they prefer to have fewer rather than more Suppliers. Our sinter parts are also single sourced.*

WHY NOT

** Preferred technologies. The Manager Engineering Projects maintains that Firm B does not have preferred suppliers, only a list of technologies and supplier firms with which Firm B has done business in the past: *These suppliers are approached first, when we try to establish the manufacturability of a product. They hear from us that it is a new product, and that they can join the bidding process. But there is no promise on our part that they will actually get the order. However, they have an advantage in that they have a relationship history with us. Their knowledge of our supplier conditions enables them to come with an optimum price quotation.* But this view is countered by the PD Engineer who notes that such approach makes the suppliers very vulnerable: *Your relationship with the supplier is important. When the supplier knows that you are serious about approaching him, he will put more time into the making of prototypes. But if suppliers don't know for sure that they will get the order, then they are not going to spend much time on prototyping. We have had a supplier firm that has done a lot of work on our design, and in the end, we gave the order to another. Well, they will not do it the second time!*

According to the Manager Engineering Projects, the reasons for choosing the current supplier of steel deep drawn stamped housing were fourfold: the geographical proximity and short lines of communication, the speed with which the supplier firm was able to modify prototypes, the energetic personality of the Supplier's Director, and the price. At one time, Management of Firm B put some pressure on (Design) Engineering to select an US supplier. The argument was that since the end product of which the steel housing was a part, was to be manufactured at the production plant in the US, having a supplier in the US would avoid currency fluctuation costs. However, the price of the US supplier was higher, and the supplier's response to requests for modification was slow. These facts made Firm B to select the current supplier.

BOX 5.4

REFLECTIVE COMMENT

The diversity in information relationships between Engineering and Suppliers is a reflection of the fact that Engineering as a profession does not represent a homogenous group. The information relationship that the (Design) Engineers in Firm B have with supplier firms is formed by the function that the (Design) Engineers hold in the course of the NPD process.

The heterogeneity in information relationships between the (Design) Engineers and suppliers is, for example, apparent from the way the (Design) Engineers approach the technical drawings. The PD Engineers and the Supplier firm's Director (i.e., the two parties directly involved in the manufacturability assessment of products) concede that the drawings of product specifications that the PD Engineers submit to the supplier firm need to evolve through the process of modification, clarification, and negotiation. Thus, the PD Engineers and the supplier firm engage in 'joint meaning-making '(Bucciarelli and Kuhn, 1997).

The Manager Engineering Projects holds a different view: *When we give our technical drawings to the Supplier, they are for 80 per cent free of errors or omissions. What is then needed is the last fine tuning.* The inverse perception with which the PD Engineers and the Manager Engineering Projects view the value of supplier's contribution to technical drawings can be ascribed to the fact that the PD Engineers and the Manager Engineering Projects have a different kind of relational ties (Granovetter, 1973, 1982) with the supplier. The PD Engineers have a close working relationship with the supplier; they see each other frequently. The PD Engineers can, therefore, witness at first-hand what and how the supplier contributes to the design process.

(continued on next page)

BOX 5.4

REFLECTIVE COMMENT (cont.)
In contrast, the relational ties between the Manager Engineering Projects and the supplier are less strong, and don't directly concern the manufacturing issues. The case evidence from Firm B further suggests that the concept of Single Sourcing and the concept of Preferred Suppliers are closely related. It could be argued that the linkage between these two approaches to sourcing is the knowledge exchange: both in the operational terms (e.g., the supplier is familiar with the ways customers run their business.) and in the capability terms (e.g., the supplier understands customer's technical requirements and has knowledge to contribute).

SALIENT ISSUES: **The strength of social ties' role in the valuation of information and knowledge exchange.**
The role of Single Sourcing and Preferred Suppliers in the context of information and knowledge exchange.

Sub-level of Supplier's Director/ Quality Control & Supplier Development Engineer

WHAT
** Dual function. Firm B had recently been through reorganization which involved moving production facilities to Ireland (a third production site of Firm B), and reducing the number of people in Quality Control and Supplier Development (QC-SD). As a result, there is currently only one Engineer who has the dual function of Quality Control and Supplier Development. The QC-SD Engineer describes his dual task as follows: *In projects I act as Supplier Development Engineer, in operational issues (product parts quality) I act as Quality Control Engineer. The field of Quality Control has shifted towards the supplier end of product development process, and in future my work should focus on Supplier Development only.*

HOW
****** Participation in the Sourcing Committee. The dual job is reflected also in the QC-SD Engineer's involvement in the Sourcing Committee. On the one hand, the QC-SD Engineer acts as Quality Control Engineer when he organizes the validation of new parts of potential suppliers. The QC-SD Engineer is in charge of the procedures of APQP (Advanced Product Quality Planning) and PPAP (Production Part Approval Process). On the other hand, the QC-SD Engineer is also involved in the decisions of the Sourcing Committee concerning which of the suppliers should become 'preferred suppliers' of Firm B. The QC-SD Engineer gives the following definition of a preferred supplier: *The preferred supplier is a firm that signed a quality contract, is certified to ISO/TS 16949 Standard, has minimal customer complaints, and its production system works at*

low ppm (parts per million) reject level. Firm B expects their preferred suppliers to have a rejection level of 10 ppm (i.e., 10 rejects per million product parts). The QC-SD Engineer comments: *That's very low, but our customers have very high requirements.* To be considered a preferred supplier, the supplier firm also needs to be certificated at least to a minimum of ISO 9001 Standard. However, the supplier firm does not need to have a Technical Specification (TS) 16949 Certification as long as the supplier firm can demonstrate that their manufacturing process operates at the TS level of quality requirements. The QC-SD Engineer notes: *We are quite headstrong when it comes to suppliers because the product parts we design are very special.* In reply to a question whether the supplier firms were also screened for their potential as a source of knowledge for Firm B, the QC-SD Engineer says: *Yes, of course, we do, but it has to take shape yet. For example, during my regular visit to a supplier firm on quite another matter, I was given a tour of the company, and saw that their injection moulding technology could be an answer to a problem that we were having with one of our product parts, and I passed that information on to the Manager Engineering Projects. The next step is for Purchasing and PD Engineers to explore the financial and technical feasibility of that technology for our firm.*

** Participation in Project Team meetings. In his job as Supplier Development Engineer, the QC-SD Engineer participates in project meetings and advises PD Engineers on the purchasing of new components. The QC-SD Engineer explains what his advice entails: *Sometimes a new product part only just meets the specification requirements, and then I need to know from PD Engineers how critical the part is. We distinguish between the dimensional validity of parts which are periodically checked and verified through the PPAP (Production Part Approval Process) procedure, and the 'special characteristics' of product parts which are defined in the technical drawings of PD Engineers. I need to know how realistic are the tolerances that are set in the drawings, and even more importantly: can the tolerances be measured? What you often see is that in drawings the tolerances are very tight, whereas in production you want to have larger tolerances. This is an area of tension on which I can give my input based on my experience with suppliers and their products. If the supplier firm, for example, is not able to achieve the required level of manufacturing capability, extra quality inspection checks must be introduced. Or, the supplier firm may ask us to increase the tolerances, and that is a matter for discussion with the PD Engineers in which I also take part.*

** Single Sourcing. Commenting on the practice of Single Sourcing in Firm B, the QC-SD Engineer notes: *Multiple or dual sourcing costs much more time and energy. Introducing design modifications means synchronizing the production process at two or more supplier firms, and that puts extra pressure on your information dissemination. We invite bids from 3-4 potential suppliers, but because you have already done business with a preferred supplier, you end up giving the order to him. This is especially the case when there are little differences in the financial/technical assessment of suppliers. With an old supplier you have a certain bond; you have knowledge about, and of the firm. Perhaps we fall back on our existing suppliers too easily. For example, we have a Japanese supplier for a vital component of our product.*

It is a very good supplier, few customer complaints, and very low ppm level, but for us it is a single source. There has been once another supplier in picture, but that firm was not as good in manufacturing and quality performance. But I cannot rule out the possibility that we shall try again to look for another supplier, simply in order to have a second source. Typical for the single source (the Engineer uses the word 'monopolist') *is that they react slowly to our modifications. We are a big customer of this Japanese firm, and yet, when we request design modifications, there are few incentives to motivate the supplier because he knows that we are dependent on him. The supplier firm has offices in Europe, visits us regularly, but important design modifications must go to Japan, and their manufacturing plants are in China and Vietnam. But there are positive aspects too. We know their product portfolio and that knowledge helps us with design modifications. With another supplier we would have to build up that knowledge from scratch.*

******** Audits and Supplier Development. At the moment Firm B takes a reactive rather than pro-active stance towards Audits. When there are problems with the production of product parts, then Firm B carries out a process Audit at the supplier site to identify the weaknesses in production. Often, the supplier firm starts with a small-series production, but encounters problems later on, with the increase of production volume.

The function of Supplier Development Engineering stems from the period when Firm B was a subsidiary of a large US automotive group. The QC-SD Engineer describes his work in Supplier Development as follows: *The objective is to help supplier firms with which we have been doing business for a long time; to help bring their production performance to a higher level. Another aspect of my work concerns advising PD Engineers on the manufacturing capability of suppliers; to see whether the firms that PD Engineers have identified as potential suppliers meet the quality requirements of Firm B.* The PD Engineer shares this view: *You always need feedback about the quality of supplier products. If there are problems with a product part that we use in our product then we need to know about it quickly.*

WHY

** PD Engineers' participation in Audits. Involving the PD Engineers in Audits is a new direction in the customer/supplier relations in Firm B. From the moment that Firm B had to reduce the number of QC-SD Engineers, there was a feeling among the PD Engineers that the 'vacancy void' should be seen as an opportunity to increase the involvement of PD Engineers in Supplier Audits and Supplier Development, and so to learn at first-hand about the manufacturing capabilities of supplier firms. The PD Engineer gives the following reasons, why he thinks the participation of PD Engineers in Supplier Audits is desirable: *I have always said that I want to see how a process Audit is done. I want to learn how the Audit works and what to look out for. It is also good for suppliers because they see which issues are for us more critical and which ones are less so. I think that it is very important that the PD Engineers know how the products they design are produced. This is especially the case now that our production has been moved to Ireland. Besides, our products increasingly consist of product parts that we have to purchase.*

WHY NOT

The QC-SD Engineer has a more nuanced view on the participation of PD Engineers in Audits: *I lead the Audit and PD Engineers are there as observers. Sometimes they would like to get more detailed information about a certain technical issue, whereas my task is to assess the quality management process as a whole. There is always an area of tension between product development and manufacturing operations.*

BOX 5.5

REFLECTIVE COMMENT

In ensuring compliance with standards and procedures for the production of product parts of Firm B, the QC-SD Engineer acts in many ways as a go-between for PD Engineers, Purchasing, and Suppliers. The exchange of information and knowledge takes place primarily through forms and protocols. However, the case evidence shows that the exchange of knowledge can also take place through personal interaction, such as in the meetings of the Sourcing Committee and the meetings of the Project Teams. The latest development in Firm B is to bring the knowledge exchange between QC-SD, PD Engineers, and Suppliers to a higher level by inviting the PD Engineers to take part in supplier Audits.

SALIENT ISSUE: **Audits and Supplier Development as mechanisms for the exchange of supplier information and knowledge.**

5.2.2 Customer's Purchasers/ Customer's (Design) Engineers dyad (CP/ CDE)

WHAT

** Chairing Sourcing Committee. The prime forum for Purchasers and (Design) Engineers to exchange information and knowledge is the Sourcing Committee. The Sourcing Committee is chaired by Purchasing and takes decisions on supplier selection. Furthermore, Purchasers also participates in the weekly meetings of Project Teams. Thus, Purchasers are in a position to influence the design process already in its conceptual phase.

HOW

***** Supplier search and selection. Although the search for suppliers is the job of Purchasing, sometimes the R&D Engineers carry out an initial search for suppliers themselves. According to the Purchasing Manager, it is more efficient that way. *The R&D Engineers know what they are looking for, whereas I wouldn't know where to start. Once they have identified potential suppliers, then Purchasing can look at the supplier's position on the market, the competitors, who are the market leaders, and the prices. For the prototype you can use a supplier round the corner, as it were, but for the ultimate product you need to scan the market.*

<u></u>** Purchasing/Engineering interface. Both Engineering and Purchasing agree that the understanding between them is good. The R&D Engineer observes that whether the relationship between Engineering and Purchasing is free of tension largely depends on the kind of people who run Purchasing. *You have Purchasers who only go for their targets. If they can get a product for a fraction cheaper, then they don't move until they get their way. And often later, in assembly, it turns out that the cheaper product is more costly to assemble … I have known such things to happen. But you have also Purchasers who look at the whole design, the total costs. And I think that the people who now work at Purchasing belong to the latter category.*

The Purchasing Manager describes the collaboration between Purchasing and Engineering as follows: *There are differences of opinion, although I must say, that compared to previous years, we now take the same line more often. In the past, the (Design) Engineers wanted to have a technically perfect product, and had no regard for product costs. The Purchaser, on the other hand, kept reminding the (Design) Engineers about the costs. And when it came to debate, the (Design) Engineers with their wish for perfection usually won the argument. Now I see that the (Design) Engineers are mindful of the fact that in the automotive industry the price is everything. As a result, the (Design) Engineers focus on minimal design, and are more willing to take on board suggestions from outside.*

The Purchasing Manager recalls an episode that epitomizes the antagonistic relationship that existed between Purchasing and (Design) Engineering in the past: *Once, during a project meeting with (Design) Engineers about the use of stainless steel in a product part, I asked: "Couldn't you use carbon steel instead?" The response of the (Design) Engineers was: "What are you worried about? You know that stainless steel is always better and, besides, we are within the budget." However, when the product eventually came on the market, it could not compete in price with competitors' products.* Some differences of opinion between Purchasing and Engineering, however, still remain as the following comment of the PD Engineer illustrates: *Purchasing department views 'preferred suppliers' differently than we do. They look at certifications and 'ppm levels'. Those are just numbers, things you tick off on a form. But if the same supplier is not able to provide the information I need, then he is of no use to me.*

The PD Engineers are in agreement that they would always prefer a knowledgeable supplier to a cheaper one, but they accept that Purchasing may take a different view on the matter.

<u>WHY</u>

<u></u>** Trust in each other's professionalism. The information relationship between Purchasing and Engineering is one of mutual dependence and trust in each other's competence. The R&D Engineer gives the following description of the interaction between Purchasing and Engineering: *Purchasing is always present during our meetings with the supplier. But when the discussion gets too technical, they take a step back and leave us to it. Purchasing wants to have a say on prices, but technical issues they leave to Engineering.*

When the Purchasing Manager is asked about whether having an engineering educational background makes his communication with Engineering easier, the reply is unequivocal: "*Yes, definitely.*"

BOX 5.6

REFLECTIVE COMMENT

In the past, Purchasing and (Design) Engineering used to belong to the opposite camps in the firm. The external factors of competitiveness in the automotive industry have brought the two camps to understand each other's viewpoints better. The understanding is enhanced when members of Purchasing staff have an engineering educational background which helps them to assess the product holistically rather than as a sum of component parts.

SALIENT ISSUE: **Engineering educational background of Purchasing staff.**

5.2.3 Customer's Purchaser/Supplier's Director dyad (CP/SSE)

WHAT

****** Entry/hurdle point. The Purchasing department is the first point of contact for suppliers. However, the Purchasing department can also represent the first hurdle that a supplier firm needs to take when trying to gain access to the firm's (Design) Engineers. The Sales Engineers in the ethnographic study of Darr (2006: 40) describe the process as: "beginning to break the doors down at the Account and gaining the rights of passage into the Engineering department". The Supplier's Director perceives his relationship with the Purchasing departments of his customers in a similar way: *We are selling knowledge. We earn our money by products, but in fact we are selling knowledge. […] At the moment I am turning down any customer who does not allow me to talk to the designer. If they ask me to give price quotations without allowing me to talk to the designer so that I can learn what the project is all about, then I am not interested. […] For the same reason I am not interested in bidding on the Internet which is about commercial feedback but not about a technical knowledge feedback.[…]. When the designer is looking for ways to produce housing/casing, he doesn't look for knowledge on deep drawn stamping. May be the designer doesn't even use our terminology. He is more interested in seeing and holding our product.* The Supplier's Director explains his customer strategy as follows: *I am not trying to get orders for all stamping parts of Firm B, for example. For an average stamping part the Purchasing department selects two or three suppliers and gives the order to the cheapest one. I am interested only in those product parts to which we can add value, because then I can get a better price.* Interestingly, Firm B in their role of tier-two supplier pursues a similar strategy when it approaches the OEM's of the automotive industry. Firm B also seeks to compete on terms of knowledge (backed up by patents). Similarly, Firm B needs to take the hurdle of the OEM's Purchasing department and its influence with regard to the selection of suppliers in order to convince the OEM's (Design) Engineers about the superior quality of Firm' B's products.

HOW

<u>**</u> Reducing production costs. Suppliers contribute to reducing production process costs and to improving production stability. The Purchasing department of Firm B is conscious of the benefits to be derived from supplier knowledge. The Purchasing Manager gives an example: *A supplier of sinter parts reported stoppages and tooling breakdowns. The supplier firm blamed the hold-ups on the form complexity of a certain product part which in their view was not critical for the end product. They argued that if the drawings were modified, and that particular product part made simpler, the production output and product quality could be increased. Of course, this is a matter of trust. We could have moved the production to another supplier. But we know from experience that our products often border on what is technically possible. So the chances are that the other supplier would have run into the same kind of problems. So we have learned to listen to supplier suggestions and modify the drawings when needed. That works out the best for everyone.*

WHY

<u>**</u> Single Sourcing. Firm B works with single source suppliers. The Purchasing Manager explains the reasons behind this choice: *Most of our product parts are single sourced. Just about all of them. It is risky, but it is a trade-off between risks and benefits of the reduced price that you get when you place a large volume order […]. My experience is that the product parts that we need for our new products are often based on, or derived from, the product parts that we purchase already. So it is not as if you would enter into a new deal with the supplier. You can build on the price agreements that you already have with the supplier. Once you divide your order volume in two parts, you lose the price reduction benefit. So we try to minimize the risks by making sure that the suppliers we select are sound financially. As Purchasing, we visit them once a year. Furthermore, we audit their manufacturing process to see if they really are a good partner for us (The suppliers need to score at least 80 points out of 100 on our assessment checklist). And from that moment on we have a single source. For example, suppose that we would have a second source for the current supplier of the new steel housing. That would mean investing in two sets of tooling and that costs 150.000 Euros a piece.* And the Purchasing Manager continues: *When we do benchmarks, it is rare that we come across a supplier with better prices than those of our current suppliers. So the long-time relationships are paying off. It has been my experience that the long relationships with suppliers are more appreciated in Germany and the Netherlands than in the US.*

BOX 5.7

REFLECTIVE COMMENT

Firms competing on knowledge, rather than on price, rely on relational assets, such as trust, competence, and benevolence between the trading partners. The case evidence shows that both Firm B and the supplier of steel housing/casing pursue this strategy. The decision for Single Sourcing must therefore be interpreted in this light. It is a deliberate choice in favour of supplier knowledge and trust. It is also a choice in favour of time and costs efficiency. The risks of being dependent on just one supplier are recognized and acknowledged, but they are not deterrent enough.

SALIENT ISSUE: **The relational assets of Single Sourcing.**

5.3 **Salient Issues in the dyadic information relationships of Firm B.**

The Within-case Analysis of the dyadic information relationships found in Firm B has resulted in the identification of the following Salient Issues:

In the dyad of Supplier's Director and Customer's (Design) Engineers (SSE/CDE), Section 5.2.1:

- Sub-level of R & D Engineers;
  Physical objects are information bearers in the conceptual design stage (Box 5.3);
- Sub-level of Project Management & Product Development;
  The strength of social ties' role in the valuation of information and knowledge exchange (Box 5.4);
  The role of Single Sourcing and Preferred Suppliers in the context of information and knowledge exchange (Box 5.4);
- Sub-level of Quality Control & Supplier Development;
  Audits and Supplier Development as mechanisms for the exchange of supplier information and knowledge (Box 5.5).

In the dyad of Customer's Purchaser and Customer's (Design) Engineers (Section 5.2.2):

- Engineering educational background of Purchasing staff (Box 5.6).

In the dyad of Customer's Purchaser and Supplier's Director (Section 5.2.3):

- The relational assets of Single Sourcing (Box 5.7).

The Salient Issues are based on the evidence obtained through product documentation, e-mails, and interviews with nine informants representing the functions of (Design) Engineering and Purchasing in Firm B, and the function of Director of Engineering & Sales in the Supplier firm. The case evidence has been described and analysed following the three Research Questions relating to the What's, the How's, and the Why's/Why not's of dyadic information relationship. A summary of the analysis is in Table 5.3. The Salient Issues of Firm B serve as input for a Cross-case Analysis (Chapter 8).

Table 5.3: Firm B's dyads

DYADS		DYADIC INFORMATION RELATIONSHIPS OF FIRM B			
		WHAT	HOW	WHY/WHY NOT	Salient Issues
Supplier's Director / Customer's (Design) Engineers Section 5.2.1	Sub-level ***R&D Engineers***	Exploring technology options. The development of new housing/casing. Supplier knowledge contribution.	Supplier search & Trade Shows. Design Review Meeting. CAD models. Adding new manufacturing solutions to the Morphological Map. The PRO-launch process.	Adopting new manufacturing technology. Costs savings. Increase the stiffness of housing/casing. Reduce the number of parts from 30 to 20.	**Physical objects are information bearers in the conceptual design stage (Box 5.3).**
	Sub-level ***Project Management & Product Development (PD) Engineers***	Manufacturability issues. Prototypes & Risk avoidance.	Frequent meetings between PD Engineers and the supplier' Engineers. Technical drawings Negotiating product tolerances and dimensions with supplier's Engineers. Monitoring costs.	Supplier selection. Preferred suppliers versus Single Sourcing. Preferred technologies.	**The strength of social ties' role in the valuation of information and knowledge exchange (Box 5.4).** **The role of Single Sourcing and Preferred Suppliers in the context of information and knowledge exchange (Box 5.4).**
	Sub-level ***Quality Control & Supplier Development Engineer***	Dual function of the Engineer: Supplier Development in projects and Quality Control in product parts selection. .	Participation in the meetings of Sourcing committee & Project Teams. Single Sourcing. Audits and Supplier Development	PD Engineers' participation in Audits and Supplier Development: pros & cons.	**Audits and Supplier Development as mechanisms for the exchange of supplier information and knowledge (Box 5.5).**
Customer's Purchaser/ Customer's (Design) Engineers Section 5.2.2		Chairing Sourcing Committee. Participation in Project Team meetings	Supplier search and selection. Purchasing/Engineering interface	Trust and respect in each other's professionalism.	**Engineering educational background of Purchasing staff (Box 5.6).**
Customer's Purchaser/Supplier's Director Section 5.2.3		Purchasing is a first entry/hurdle point for suppliers.	Reducing production costs and improving production stability.	Single Sourcing.	**The relational assets of Single Sourcing (Box 5.7).**

Chapter 6: **The Within-case Analysis of Firm C**

6. Introduction

Firm C is a multinational tier-one supplier of pneumatic and electrical components and assemblies for industrial and process automation. The present case study has as its background a widely publicized and exhibited product concept of a Gripper component that adapts to the shape of a work piece just as the fingers of human hand would do. The case study examines the internal information relationships in two subsidiaries (national and regional) of Firm C, and the firm's Headquarters. Furthermore, the case study focuses particularly on the information relationships that Firm C has with the (Design) Engineers of customer firms. The case vignette in Section 6.3 describes the role that the information relationships play in customer pilot projects and in the development of new products, such as the Gripper component. By focusing on the information relationships that Firm C maintains with its customers (rather than with suppliers as is in Firms A, B. and D), the present case study helps illustrate the duality of the utilization of supplier information and knowledge, as an output and input for the FFE of NPD.

As shown in Table 6.1, in the case studies of Firms A, B, and D, the utilization of supplier information and knowledge was an outcome (output) of the information relationships between the Firms A, B, and D and their respective suppliers.

Table 6.1: The duality of supplier information and knowledge.

Utilization of supplier information and knowledge at the micro-social level of the firm can take the form of:	
Input when:	*Output when:*
The information relationship is between a firm in its role as supplier and its customers. E.g., the case study of Firm C. The supplier information and knowledge originate in Firm C (i.e., the supplier).	The information relationship is between a firm in its role as customer and its suppliers. E.g., the case studies of Firms A, B. and D. The supplier information and knowledge originate in the supplier firms.

By comparison, in the case study of Firm C, the utilization of supplier information and knowledge is a starting point (input) for the information relationship between the Subsidiaries of Firm C and their customer firms. The informants taking part in the case study came from the Headquarters of Firm C (2), the National and the Regional Subsidiaries (5), and from customer firms of the Subsidiary firms (2). The figures in brackets give the number of participants.

The analysis of Firm C proceeds in two steps shown in Table 6.2. Step 1 describes the external information relationships of Firm C in general. It outlines the information relationships arising from R&D collaboration in Bionic Technology and the Bionic Technology Projects. Step 1 concludes with the researcher's Reflective Comment (Box 6.1).

Step 2 examines the dyadic information relationships at the micro-social level of Firm C, including the information relationships during the Gripper component pilot project (a case vignette in Section 6.3). The composition of the dyads reflects the customer orientation of the case study, and involves the Sales Engineers and (Design) Engineers of Firm C and the (Design) Engineers of customer firms.

Table 6.2: Steps of analysis of Firm C

Step 1	External information relationships of the firm.	External information relationships of Firm C (Section 6.1) arising from R&D collaboration in Bionic Technology and the Bionic Technology projects. (Section 6.1.1).	**Outcome:** Reflective Comment made by the researcher on external information relationships (Box 6.1).
Step 2	Micro-social level information relationships of the firm.	Information relationships of the dyads of Firm C: Supplier's (Design) Engineers/ Supplier's Sales Engineers (Section 6.2.1). Supplier's Sales Engineers/ Customer's (Design) Engineers (Section 6.2.2). Supplier's (Design) Engineers/ Customer's (Design) Engineers (Section 6.2.3).	**Outcome:** Salient Issues in information relationships for each dyad, supported by the researcher's Reflective Comments (Boxes 6.2 – 6.4).
		The Gripper component pilot project (a case vignette) (Section 6.3).	Researcher's Reflective Comment (Box 6.5)

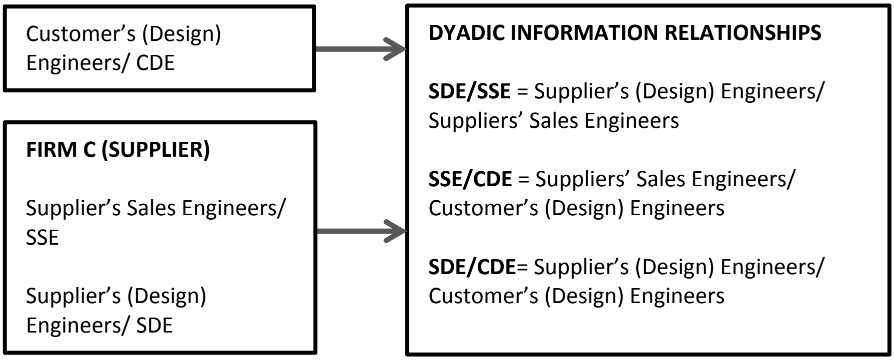

Figure 6.1 Schema of the case study of Firm C

As shown in Table 6.2, and illustrated in Figure 6.1, the configuration of the studied dyads is as follows:

- Supplier's (Design) Engineers and Supplier's Sales Engineers (Section 6.2.1);
- Supplier's Sales Engineers and Customer's (Design) Engineers (Section 6.2.2); and
- Supplier's (Design) Engineers and Customer's (Design) Engineers (Section 6.2.3).

The analyses of the dyadic information relationships are structured round the Research Questions, and focus on the What's, the How's, and the Why's/Why not's of the information relationships. A summary is given in Table 6.3. The analyses conclude with the identification of Salient Issues for each dyad, supported by the researcher's Reflective Comments (Boxes 6.2-6.4). The Salient Issues serve as input for the Cross-case Analysis in Chapter 8.

6.1 **External information relationships of Firm C**

Firm C is a family-owned firm with autonomous subsidiaries in 59 countries and more than 300.000 customers world-wide. Firm C produces some 30.000 catalogue products in several hundred thousand variants for applications in pneumatic and electric automation of industrial processes. Four factors play a determinant role in external information relationships of Firm C.

The first factor is the firm's R&D (Research and Development). Firm C spends 8, 5% of their turnover on R&D. Historically, all R&D activities have been concentrated at the Headquarters (HQ), whereas Subsidiary firms performed primarily the sales and customer support function. Increasingly, however, the Product Manager at the HQ seeks the assistance of his counterparts at Subsidiary firms to help find candidates among the current customer firms to participate in R&D pilot projects. In such situations, the Product Manager of Subsidiary firms acts as a go-between: transferring prototypes from the HQ to customers, and forwarding test findings from customers to the Product Manager at the HQ. The Product Manager at the HQ, in his turn, transfers the feedback from the pilot projects to R&D staff members who had been assigned to the project.

The second factor that typifies the external information relationship of Firm C is the firm's commitment to training and education. In fact, the training and education programmes of Firm C represent an independent business sector of the firm. The subsidiaries of Firm C have responsibility for their own training and education programs, which means that the education programmes can take specific local and cultural requirements into consideration. The objective of the training courses is to transfer the product knowledge of Firm C to customers. The courses aim to show the customers how to use the products of Firm C effectively so as to increase their own productivity. At the same time, the courses teach the customers to view production processes holistically, to look beyond the performance of the single product parts.

The third factor that is characteristic for the external information relationships of Firm C is related to the shift in customer needs: from single products to turnkey systems. This shift puts extra demands on the Customer Solutions division of Firm C that is responsible for the development of Special Applications for customers. Increasingly, the turnkey solutions need to incorporate knowledge that is not part of the traditional knowledge base of Firm C. The growing complexity of automated production and automated systems, coupled with the drive for environmental sustainability, has presented Firm C with a challenge to seek knowledge from outside its core technologies of pneumatics, electronics, and mechatronics.

The fourth factor that is determinant for the external information relationships of Firm C is the prominent role of design. The approach of Firm C to design is twofold.

There is the traditional approach: design as a means with which to differentiate the firm's 30.000 pneumatic and electrical components from the products of competitors. This focus on design in engineering and product quality has borne fruit: throughout the years, Firm C received some 70 national and international design awards. The other approach to design is less conventional. Firm C uses design as a platform for exchanging ideas and knowledge with research institutes, with the aim to pioneer new applications in automation technology. Every year, Firm C sponsors one or more design projects that have as the theme 'learning from nature'.

6.1.1 Information relationships arising from R&D collaboration in Bionic Technology

Firm C takes part in a R&D network of institutes and universities that carry out research in the fields related to bionic technology, such as biomechanics, kinetics, aerodynamics, and biomimicry. Significantly, the bionic design projects that Firm C annually sponsors fall under the department of Corporate Design. The Director Corporate Design sums up the ideas behind the projects as follows: *We are convinced* *that it is worthwhile to look at nature and the solutions that nature provides. You discover that nature is so fascinating that you cannot rebuild it. So you are learning all the time. And what we learn, we try to interpret in a new way.* By sponsoring projects in which knowledge of diverse disciplines is combined, and incorporated in new automation solutions, Firm C adopts the position of a knowledge broker. The bionic design projects bring about cooperation of disciplines that would otherwise not take place. In the words of Director Corporate Design: *Traditionally, biologists don't talk to engineers. It's really a problem of communication and understanding. They don't trust each other. In the past years we have had the interpreter's role between the biologist and the engineers. That was our job.* A study of patent literature (Vincent et al., 2006) reached a similar conclusion, and brought to light the reasons behind this communication gap. It showed that there was only 12% similarity between biology and technology in the way that the two disciplines approached solutions to problems. Whereas technology solves problems largely by manipulating usage of energy, biology solves problems by using information and structure of living systems.

For Firm C, the bionic design projects are not only an opportunity to learn but the projects are also a medium for communicating the firm's vision on innovative automation concepts to their customers, and to the world at large. The strategic importance of the bionic design projects also transpires from the fact that the decision making on the direction and focus of bionic projects is in the hands of the firm's Management Board.

The Bionic Technology Projects

The annual bionic projects of Firm C have so far resulted in working prototypes of human-like or animal-like robots that move in water or in the air, or perform 'pick and place' tasks. Each year the presentation of a new bionic design project is a major publicity event which is usually tied in with a worldwide conference or trade show, or even an art exhibition.

One of the stated objectives of the bionic design projects is to discover and find inspiration from the motion and control principles found operating in nature, and use these principles to further optimize automation solutions in the future. However, the bionic design projects have other objectives as well. The Director Corporate Design comments: *Most people think that we have to develop new products, but that is only one of our seven tasks. For example, positioning our brand in the world, or employer branding would be our other objectives. Getting young people excited about technology, to motivate them to study engineering would be another. With regard to product development: through these projects we test reactions of people to ideas before doing any research. When you see how much testing is required and how long it takes before producing a product that meets our quality criteria; it's really very expensive. When we do tests through a bionic design project and there is little interest in the product concept, it's not a problem. We may return to it in five years' time.* Time to market does not seem to be a consideration in bionic design projects, as the development of the Gripper component demonstrates. At least ten years have elapsed between the first discussions about adaptive grippers and the presentation of a working prototype at a major trade show.

The structure of the Gripper component is based on two patents, owned by two different research organizations in the field of bio-mimicry and vacuum technology. Firm C had contacts with these organizations through the R&D network, and acquired the rights to use the patents. Firm C already had grippers in its product assortment, and wanted to optimize the application and performance of the extant grippers in terms of weight and flexibility. This fact notwithstanding, Firm C decided to develop the prototype to commercial product only after a prototype of the Gripper component had been successfully presented at a trade show. The feedback that Firm C received from the trade show's visitors was a strong enough indication that there was a market for a Gripper component that was lightweight and flexible enough to handle fragile work pieces of varying shapes and sizes. The Gripper Component pilot project is the subject of a case vignette in Section 6.3 and the researcher's Reflective Comment in Box 6.5.

BOX 6.1

REFLECTIVE COMMENT

In using trade shows as a venue for design concept testing (Bello and Barczak, 1990), Firm C follows in the footsteps of the automotive industry which uses the 'concept car strategy' extensively (Roscam Abbing, 2010). Concept cars are not meant for production but are used by car manufacturers as means for learning about the reactions of both the public and the car industry professionals.

Buijs (2012) introduced the term 'Projecta' to designate concrete look-a-likes of new future products. Analogous to Persona (a fictional character of the future user), the Projecta is the ideal demonstration project for showing the design qualities of a company or a brand in order to get or provoke feedback from relevant third parties.

Firm C adds an extra dimension to this strategy, when it adopts the role of a knowledge broker and initiates a cross-fertilization of scientific and technical disciplines.

6.2 Micro-social level information relationships of Firm C

The case study investigates the role that the information relationships play between Firm C and its customers in the development and introduction of new product concepts, such as the Gripper component.

The case study informants came from the Headquarters (HQ) of Firm C, the National and Regional Subsidiaries of Firm C, and two customer firms of the Subsidiaries. The informants represented the following functions: (Design) Engineering (3), Product and Project management (2), Sales Management (2), and Sales Engineers (2). The figures in brackets give the number of participants.

The analysis of dyadic information relationships concerned the micro-social level of the National and Regional subsidiaries, and where appropriate, also the micro-social level of HQ (Section 6.2.3).

The case vignette in Section 6.3 concerns the Gripper component pilot project. It gives an overview of the information relationships of the participating (Design) Engineers, Product Managers, Sales Engineers, and follows the project's beginning, progress and completion.

The analysis of the dyads has been guided by the Research Questions, and focuses on the What's, the How's, and the Why's/Why not's of information relationships. The analysis concludes with the identification of Salient Issues in each of the dyadic information relationships, and provides the researcher's Reflective Comments. Table 6.3 gives a summary of the analysis, with the Salient Issues listed in the last column. The Salient Issues serve as input for the Cross-case Analysis in Chapter 8.

6.2.1 Supplier's (Design) Engineers/ Supplier's Sales Engineers dyad (SDE/SSE)

The (Design) Engineering division in Firm C is known as Customer Solutions. The task of Customer Solutions is to add value to the existing product assortment of Firm C by developing customized versions, the so-called Special Application (SA) of product parts at customers' request. Customer Solutions can also develop and produce turnkey systems as solutions to customer problems. In developing the turnkey systems, Customer Solutions utilize product parts of Firm C in novel combinations. Customer Solutions can undertake such projects alone, or they can outsource part of the development to the Solutions Engineering Centre (SEC) at the Headquarters (HQ). Here it is important to note that Customer Solutions play no part in the development of completely new products such as, for example, the Gripper component. It is only when the Gripper component is released and becomes part of the product assortment (i.e., it becomes a catalogue product of Firm C), that the division Customers Solutions can deploy the Gripper component in Special Applications.

The information relationships between Customer Solutions and Sales Engineers at the two Subsidiaries are influenced by a number of factors of which the size of the Subsidiary firm is one. The sales force of the National Subsidiary is about four times bigger than the sales force of the Regional Subsidiary. The capacity of Customer Solutions of the National Subsidiary is also bigger than that of the Regional Subsidiary.

The Subsidiaries operate as autonomous entities and are free to develop their own policy on customer relationship. The autonomy is apparent from the different conceptions that the Subsidiaries hold about the role that the Sales Engineers should play in the exchange of knowledge between Firm C and its customers.

The autonomy comes particularly to light when examining the information relationships of the three dyads shown in Figure 6.1. Therefore, the next sections will discuss the dyads in a comparative manner, that is, look separately at how each dyad functions at the National Subsidiary and at the Regional Subsidiary.

Starting with the Supplier's (Design) Engineers/ Supplier's Sales Engineers dyad, the next paragraphs will show that whereas the 'What' of the dyad is the same at both the National Subsidiary and the Regional Subsidiary, the 'How's and the 'Why's/Why not's' of information relationships show marked differences.

Given the fact that the case evidence is in places quite detailed, the text works with graphic symbols in order to ensure legibility. Each time a new facet, or stage, in the dyadic information relationship is introduced, the text paragraph is indented, and marked with **.

WHAT *(NATIONAL & REGIONAL SUBSIDIARY)*

** Signalling needs. The exchange of information and knowledge between the Sales Engineers and the (Design) Engineers (i.e., the division Customer Solutions) concerns the signalling of the need for and the feasibility of developing a Special Application for a customer.

HOW: *the NATIONAL SUBSIDIARY*

****** Customer differentiation. The size of the sales force in the National Subsidiary is large. It consists of Sales Engineers, Industry Segment Sales Managers, and Product Managers with their Technical Support (36 people in all). The Sales Engineers and Industry Segment Sales Managers are organized according to four industry segments (defined by the industry classification scheme of Firm C). In contrast, Product Managers with their Technical Support are organized according to four large product categories. The responsibilities and lines of accountability also differ.

The Sales Engineers and Industry Segment Sales Managers are responsible for the customer base. Their main focus is on the sale of the entire product assortment in a particular industry segment for day-to-day operations of customers. The Product Managers, on the other hand, are responsible for positioning their product category on the market through providing technical support and expertise to the Sales Engineers in their industry segments. The Firm C's job description for a Product Manager describes Product Managers as 'sales people for their products, with Sales Engineers as their first customers'. Together, Sales Engineers, Industry Segment Sales Managers, and Product Managers with Technical Support strive to achieve an increased sales turnover for the National Subsidiary.

** Referral and liaison. The information relationship between Sales Engineers (24-25 people) and Customer Solutions (30 people) in the National Subsidiary is one of referral and liaison. The Product Manager outlines the procedure: *When the Sales Engineer identifies an opportunity for a Special Application, he first must make a judgment of how many product parts from the Firm C's product assortment the new design will require. Can the*

Special Application (SA) lead to increased turnover? The Sales Engineer refers the request to Customer Solutions by filling in an intake form. The request is then evaluated for its commercial and technical feasibility. The feasibility of SA project is based on a number of criteria, such as:

- the buying potential of the customer (Will the Special Application lead to more purchases?);
- the product design time and capacity of Customer Solutions (How much time will the development cost? Will the project require the help from the HQ?); and
- the position of the customer in the customer pyramid (Does the customer belong to the top 20-30 customers?).

When the evaluation is positive, the formation of a team follows. The Manager of Customer Solutions describes the team approach as follows: *We often talk about 'team –selling', and what we mean by that is that the customer is given a central position in the team, and representatives of any division (e.g., Product Managers, Industry Segment Sales Managers, Finance, etc.) that can contribute to solving the customer's problem are invited to join the team. We determine beforehand what we want to achieve in terms of future sales turnover with the customer. Of course, you can't do this for every customer because then you would spend too much time in meetings, but we do it for our top 20-30 customers.* Within the team, the division Customer Solutions is responsible for design and manufacture, and for the contacts with the HQ. When the project is completed, the Sales Engineer resumes his liaison role with the customer. The Sales Engineers themselves have no direct contact with the HQ; the contact person for them is the Product Manager.

<u>**</u> Special Applications. During the past ten years the division Customer Solutions has seen a growing demand for Special Applications and the turnkey systems. The Manager of Customer Solutions ascribes this trend to the large amount of product parts available (some 30 000 parts, with about 7.000 new/improved product parts being added to the product assortment each year): *We increasingly hear our customers telling us: "You know much better than we do which product components we need. Our problem is to move an object from A to B. This is the object's weight, these are the required cycle times, and this is the budget that we have. Come with a proposal."* Most of the requests that the division Customer Solutions receives originate with the Sales Engineers. The Manager of Customer Solutions comments: *The customers for whom we have done projects in the past may turn directly to Customer Solutions, but the main point of contact for customers is the Sales Engineer. We see Sales Engineers as ambassadors of our firm.* The percentage of orders that come either through Sales Engineers or through Customer Solutions is not known. The Manager of Customer Solutions: *It's not something that we register. I think that 10-20 per cent comes directly through Customer Solutions. There are customers who want a further modification of a product that we had developed earlier, and then the customers turn to the Engineer with whom they had worked previously.*

** Organizational structure. On hearing a suggestion of the interviewer that incorporating Product Managers in the division of Customer Solutions could perhaps be in the interest of more intensive knowledge exchange between the sales force and Customer Solutions, the Manager Customer Solutions acknowledges that this is an issue: *Well, Product Managers are more sales oriented. We have had this discussion before but the current situation suits our market better. But what you see is that it is often difficult to provide good answers to customer questions about product application possibilities, simply because there is no good way to answer such questions. The Product Managers are knowledgeable about their own product category, but the products are getting complex. Ten years ago, we had a product and that product was made to certain technical specifications. Today, our products are no longer based only on technology of mechanical engineering, but on other technologies as well. Often, people's education encompasses one discipline only, and they need to undergo further training in automation and control engineering, for example. It would help if we could be more application-oriented.*

Interestingly, the organization of the Customer Solutions division (30 people) does not follow the lines of industry segments (as Sales Engineers and Industry Segment Sales Managers do), nor does the division Customer Solutions follow the line of product categories (as Product Managers with Technical Support do). Instead, the division is organized according to the three key areas of technical knowledge and expertise of Firm C, namely: 'motion & control'', 'smart cabinets' and 'Special Application prototyping', and grouped into sections of (Design) Engineering, Production and Service. The Manager of Customer Solutions clarifies the reasons behind this approach: *We do not focus on any industry segment in particular. But it's true that some industry segments are better represented in our projects than others. We have done industry segmentation in the past, and perhaps we will return to it in the future. At the moment, however, the (Design) Engineering section consists of 16 Engineers and then you don't achieve enough critical mass in attention per industry segment. So it was a conscious choice not to do it for the time being.* The Manager Customer Solutions further points out that: *The division Customer Solutions has undergone continued growth in the past years. Currently, more than one third of the total turnover comes from Customer Solutions. But of course, we have to admit honestly that part of our turnover derives from the work of Sales Engineers. Although we encourage that the (Design) Engineers of Customer Solutions have direct contacts with customers, these contacts usually pertain to further development of earlier projects, or take place as part of the team-selling process.*

There is no rivalry between Sales Engineers and Customer Solutions as to who brings in more sales. The Manager Customer Solutions notes: *We are all part of a team. The sales turnover is an important objective which is also set in our MBO goals (Management by Objectives), and for this we need assistance of Sales Engineers. There is always a certain tension between Sales Engineers and Customer Solutions in the sense that Sales Engineers want to sell everything, whereas the (Design) Engineers need time to think about product design and how the product can be manufactured. So it's a healthy tension between a commercial drive on the one hand, and a reality check on the other.*

The manufacturability is important and we must make good margins on the product. So it is not a rivalry in the sense that someone would go and visit a customer without informing others. Records of the visits to customer firms whether by Customer Solutions, Product Managers, or Sales Engineers, are filed in a customer database.

****** Customer database. The Product Manager describes the use of the database as follows: *We read the notes before we visit the customer. But there is no one who would actually search through the database. That is not our job; we must meet our sales targets. We are not a research institute; we are not an organization that only studies reports and notes. We must meet the sales revenue target, and the Sales Engineers need to reach their annual sales quota. For the rest, it is a question of personal communication. If I, as Product Manager, have a new product, then I know which team I should approach for a pilot project. If necessary, the responsibility for a project can be made part of the employee's MBO (Management by Objectives) goals, but then the responsibility is clearly defined.*

***HOW:** the REGIONAL SUBSIDIARY*

** Customer differentiation. The Regional Subsidiary is small and has a flat organization structure. The Regional Subsidiary differentiates its customers with the help of a customer pyramid, but unlike in the National Subsidiary, the focus is less on customer profitability, and more on customer needs. The sales force consists of eight Sales Engineers and one Sales Manager. There are no Product Managers and no Industry Segment Sales Managers. The sales force is not organized along the lines of industrial segments. Instead, the organization follows the principle of matching the customer needs with the capabilities of Sales Engineers.

The Sales Manager explains: *We don't have enough customers in one segment to be able to assign one Sales Engineer to it, and he could not achieve a turnover of let's say, 3,5 - 4 million Euros. Moreover, I am not sure that the manufacturers from the same industry segment actually have common interests. But I am quite sure that the machinery series manufacturers do have the same interests. They want the cheapest and most valuable solutions. And it does not matter whether the solution comes from the food sector, wood machines, or textile machinery. For example, one of our Sales Engineers has in his sales area several industry segments (automotive, textile, wood). And sometimes he can pass on good solutions from textile machinery to automotive lighting. He can do that because these two firms are not competitors of each other. So the Sales Engineer has a wider view, he does not just focus on one segment.*

The capabilities of Sales Engineers are based on an extensive knowledge of how product parts of Firm C have been applied in previous projects. This way, Sales Engineers are able to recommend the right product parts to meet the customer needs.

****** Sales Engineer's capabilities. A very important capability/skill of the Sales Engineer is the ability to prepare a technical drawing of a proposed product, or product improvement, and to discuss the drawing with the (Design) Engineers of the customer firm. A Sales Engineer underlines the communication value of drawings:

Here you see a drawing from a customer, and then I made a new drawing, with more detail and explanations how the proposed solution works. And it is this drawing that is being used now. It is not that I would be using more product parts of Firm C in my proposal, but there is more detail in my drawings. I provide more information so that it's easier for the (Design) Engineers of the customer firm to ask questions. We understand each other; the drawing makes my relationship with the (Design) Engineers deeper. Making the drawings has cost me half an hour, but it helped me get better and more contact with the customer.

Questioned whether anyone in the customer firm actually reviews his drawings, the Sales Engineer replied: *No, nobody checks the drawings. They trust us. They buy and apply the product parts that we suggest in the drawings.* When asked further, whether the (Design) Engineers of the customer firm were not resentful, when the design solution came from an outsider, the Sales Engineer responded: *Why should they? I have very good contacts with all of them. They invite me and say: "We know that you have good ideas and that's why we want to talk with you."*

The Sales Manager is well aware of the value that co-designing by the Sales Engineer can mean for the pre-sales period: *In this business, when a Request for Quotation arrives, it means that a lot of thinking has been done already. Someone has been steering the project and deciding which products to choose, and when they should be delivered. And our business is to provide support during the time before the Request for Quotation is placed. That's how I see it.* The flat organization structure and short communication lines means that the Regional Subsidiary is able to quickly respond to the changes in customer needs.

****** Organizational structure. The information relationship between Customers Solutions (two Engineers) and Sales Engineers (eight Sales Engineers and one Sales Manager) in the Regional Subsidiary is one of close cooperation. Customer Solutions have a back-up function for the Sales Engineer. The lines of communications are short. The Sales Engineer approaches the Engineers of Customer Solutions in person. When the Sales Engineer contacts Customer Solutions, it is to get feedback from Customer Solutions so that he can proceed with the customer's product development. Alternatively, the Sales Engineer may request Customer Solutions to develop product parts for the customer, or he may invite Customer Solutions to join a project team. Thus, the degree in which Customer Solutions participate in customer's product development depends on the time and skills that the Sales Engineer is able to provide.

The contacts between the Regional Subsidiary and the HQ are done by phone or by e-mail. Only in cases of complex Special Applications will there be an intake form to fill in. The Sales Engineer notes that the intake form is more *a checklist to make sure that none of the requirements of the customer have been forgotten.* All projects of Customer Solutions are carefully documented, include photos of new product combinations, and are filed in a database for future reference.

The Sales Engineer illustrates his way of working: *I contact the HQ when I want to make a Special Application, and I need information about the compatibility of product parts. I contact Customer Solutions here if I need to have detailed information about the material composition of a certain product part. If the Special Application represents a big project, we form a team. When the HQ Engineers don't have the time to do it themselves, we make our own team, and as a team we visit the customer, and take the work away with us. On the whole, it is the Sales Engineer who is in charge of Special Applications.*

WHY: *the NATIONAL SUBSIDIARY*

** MBO (Management by Objectives). The organizational structure of the National Subsidiary is guided by the theory of Management by Objectives (Drucker, 1954) whereby Management and employees jointly define and agree on a set of objectives, and whereby each employee is accountable for his/her share in achieving those objectives within a given time framework. The main objective of the National Subsidiary is to increase sales. This objective even pervades activities that have seemingly another purpose, as in the case of Special Application projects. Consequently, working in a team to solve a customer's problem is referred to as 'team selling', and is preceded by setting up a desired sales turnover target. The 'ambassador' role of the Sales Engineer is also interpreted in terms of driving the sales.

WHY: *the REGIONAL SUBSIDIARY*

** Matching customer needs. The organization structure of the Regional Subsidiary is guided by the principle of finding a match (fit) between the capabilities of Sales Engineers and the needs of customers. The objective is to achieve sales through relationships based on the exchange of knowledge and mutual trust. The task of the Sales Engineer is to embody and externalise the knowledge base of Firm C through his relationship with the customer.

WHY NOT *(the NATIONAL & REGIONAL SUBSIDIARY)*

** Industrial segmentation. Once the National and the Regional Subsidiaries consider knowledge management issues, they consciously decide against adopting an approach of industrial segmentation. The division Customer Solutions at the National Subsidiary deliberately departs from industrial segmentation although it is common practice throughout the firm. The Regional Subsidiary also makes a conscious choice for not adopting industrial segmentation. The advantage of industrial segmentation is that it allows comparing and measuring results, but the same advantage does not serve the exchanges of knowledge well where the outcome is often uncertain.

BOX 6.2

REFLECTIVE COMMENT

The chief advantages of Management by Objectives (MBO) as practiced by the National Subsidiary of Firm C are the clarity of goals, measurability of results, and the use of target dates. MBO works well for firms that equate their performance with their annual turnover. However, when looked at in terms of competitive advantage, the goal of achieving high sales is a short term goal. Moreover, such goal holds an inherent danger that the sales efforts can be replicated by competitors. An alternative is not to follow the established markets but to create new ones through innovation and product development. In the context of the two Subsidiaries of Firm C, product development means: keeping abreast of the growing number of applications that the product parts of Firm C can be used for, and applying this knowledge in the customer's NPD.

The MBO approach is less suited for organizations that seek to promote the exchange of information and knowledge. Knowledge and information are intangible resources which can strengthen the firm's internal capabilities (Teece, 2007; Tidd, 2012), but they are difficult to measure, and their applicability can rarely be determined within a specified time frame. In the MBO environment, studying records of visits to customers may therefore seem unproductive, although a systematic search through the records could lead to discovering untapped customer needs and new business opportunities. Alternatively, the searches could reveal that that the records about customer visits have actually low information value for NPD because the records have been written from a commercial perspective only.

By comparison, the Regional Subsidiary has chosen to pursue its sales strategy through the exchange of knowledge which is grounded in the information relationships between the Sales Engineer and the (Design) Engineers of customer firms. The Sales Engineer fulfills the role of a knowledge worker (Darr, 2006). The Sales Engineer cooperates closely with Customer Solutions; there are no intake forms to fill in. The Sales Engineer has also direct contacts with the Customer Solution division at the HQ. Together with Customer Solutions, the Sales Engineers forms a team, the primary objective of which is not selling but building up a relationship with the customer, which ultimately results in sales. By the same token, the Sales Engineer becomes a sparring partner for the (Design) Engineers of the customer firm, and so gets access to early stages of customer's product development.

SALIENT ISSUE: **Organizational forms of information and knowledge exchange.**

6.2.2 Supplier's Sales Engineers/ Customer's (Design) Engineers dyad (SSE/CDE)

The years 2010 and 2011 (the period in which the interviews with the informants were held) had been top years for Firm C, with each year exceeding the sales figures of the previous year.

***WHAT:** the NATIONAL SUBSIDIARY*

** Contacts with customers. The Product Manager speaking on behalf of Sales Engineers (24-25 people in total) gives a following description of the Sales Engineers' relationships with customer's (Design) Engineers. *Every Sales Engineer has 50-60 customers and he makes about 40 visits per month that means 480 visits to more than 50 customers each year. He is accountable for the number of visits per day. Sales Engineers have to visit more than three customers in a day. They work to a very tight schedule. That's why we keep work activities, such as participating in meetings, committees away from them. Their task is to meet their sales targets. The Sales Engineer sells the entire assortment of catalogue listed products within his industry segment. There are 4-5 Sales Engineers working in the same segment but in different parts of the country. Sales Engineers and an Industry Segment Sales Manager form a team and have commercial responsibility for the product.* According to the Manager of Customers Solutions the average annual turnover of a Sales Engineer in an industry segment is about
2-3 million Euros.

***WHAT:** the REGIONAL SUBSIDIARY*

** Contacts with customers. The Sales Engineer describes his relationship with customer firms as follows: *We sell knowledge by trying to find the right solution for the customer. The problem solving aspect of our work is important when using intelligent products, and when the inside of the products is complex. Our products can be applied in a number of different ways, and the customer turns to us for advice. For the sales of product parts, customers can contact our back office. My task is to advice on technical and engineering matters. There are always similarities among the machines, or there are past solutions that one can use. I have 35 customers, and make 400 visits a year. My sales target for 2009 was 3, 5 million Euros, and this year (2010) I expect 5, 5 million Euros.*

***HOW:** the NATIONAL SUBSIDIARY*

** Working approach. The Product Manager gives a description of how the sales force at the National Subsidiary works: *The Sales Engineers report the achieved results to the Industry Segment Sales Managers, and the Industry Segment Sales Managers, in their turn, report to the Sales Manager of the National Subsidiary. The Industry Segment Sales Managers have 1-2 times per month a coaching day with their Sales Engineer, meaning that on that day they visit the customers together with the Sales Engineer. In cases of complex problems at the customer site, the Sales Engineer may be joined by the Product Manager or the Sales Manager.* The Sales Engineers concentrate on the core customers of the National Subsidiary. The firms that belong to the category of small customers are taken care of by a network of twelve Dealers.

** Dealers network. The Manager Customer Solutions points out the advantages of working with Dealers. *We have an online purchasing system. But what you see is that small firms often prefer to buy products locally and to have technical support in their own locality. We see the Dealers as our customers and our partners. The Dealers report to our group "Dealers and Top Target Customers". The Dealers have of course their own markets. We want them to sell our products and provide service, and we support them by organizing technical training for their staff.* In reply to a question whether the Dealers act as a sort tier-two Sales Engineers, the Manager Sales Solutions says: *Yes, and we consult with them about our goals. We also evaluate the dealers' performance on a regular basis. If they so wish, we can accompany them to their top ten customers to whom they supply our products, and we can help them solve customers' problems. For our part, we rely on Dealers to help us in cases of a technical breakdown at a customer site. For example, in situations of machine breakdown, we first check which of the twelve Dealers is in the vicinity and could fix the problem. There is also active monitoring of customers. When a Dealer's customer grows too big for the Dealer, the customer is transferred to us. The reverse is also possible. When a customer does not need any more assistance from us, he is referred back to the Dealers network. This way we give form to our partnership.* The customer firms of the National Subsidiary may, however, hold a different view about Dealers, as shown in the following comment of the Director and (Design) Engineer of a customer firm: *Personally I want to be informed about the latest news in product development, to have samples of prototypes in my hands, and to test them. For that kind of information I need to have direct contact with Firm C. The Dealer has only products that have already been released and that can be found in the catalogue.* The Director also regrets the frequent personnel changes among Sales Engineers: *The present Sales Engineer has only been coming to our firm for the past half year or so. We had periods without a Sales Engineer, or we had a Sales Engineer from another part of the country. It's a pity really. It's much better to have the same contact person. With another supplier firm I have had the same Sales Engineer for ten years. I regard the Sales Engineer as a Salesman. I may occasionally ask him about what he considers feasible, but for questions about complex technical issue he brings someone from Customer Solutions with him.* Thus, approaching customers through Dealers could be viewed as efficient, but lacking in the attention to detail that a face-to-face exchange of information and knowledge provides.

HOW: *the REGIONAL SUBSIDIARY*

** Working approach. The customers of the Regional Subsidiary are divided into three groups: the customers that produce special machinery, customers that produce machinery series, and the rest, the so called 'field' group. The first two groups represent some 140 core customers with an annual turnover of 100,000 Euros, and more. The assumption behind this approach is that the manufacturer of machine series and the manufacturer of special machinery have quite different needs. The first group wants to have the cheapest solution possible, whereas the latter group strives for the most optimal solution, and is therefore less concerned about the costs. The 'field' group represents smaller customers, but they get the same amount of visits as the core customers. The Regional Subsidiary does not work with Dealers.

The Sales Manager explains how the working approach of the Regional Subsidiary differs from that practiced in the other subsidiaries of Firm C: *The other subsidiaries structure their sales territories the way we used to do in the past. They visit the big customers who expect that Firm C helps them with their projects. The consequence of this is that there is no time for smaller companies. And one forgets that in the total turnover of Firm C, small firms represent a considerable share. Often, the small companies are making a fine profit, and they get a visit from us only once a year. That's not good because that way we give our competitors opportunities.* The Sales Manager puts forward the following justification for the working approach of the Regional Subsidiary*: I believe very strongly in relationships. We have to know what's going on at our customers; we need to know the chief players. And that we cannot learn by visiting them just once a year. Our Sales Engineers need to see the customers and talk with them. A phone call is not good enough. We started this approach last year, and as it turned out, the current climate of economic downturn was exactly the right time for it. The big customers started to think more about solutions, and they needed more time from us. And the smaller firms are also happy about more visits from us. We now have more projects with them.*The Director and (Design) Engineer of a customer firm compares the work of the Sales Engineer of the Regional Subsidiary with the work of their Japanese competitor: *The Japanese firm has also a Sales Engineer but he is not as active as the Sales Engineer of the Regional Subsidiary. He just says: "This is our catalogue, look up the product that you want." Our firm may use other suppliers for series parts but for our development we prefer the Regional Subsidiary. Besides, we don't want to change the winning team.* The Sales Engineer laughingly points out that his work may even have repercussions for his social life. *When I help a customer, he is happy with my work and he buys my product. When he is not happy because I am trying to sell him something that he neither wants nor needs, then I am out of business. I also live in this area, and it's not a large area, and so I also meet customers socially. So if they are not happy with my work, they won't say "hello", but punch me instead…"* Sometimes the Sales Engineer's work can extend to consultancy.

<u>**</u> Consultancy. The Sales Engineer recounts how he once advised a customer firm on outsourcing: *It can happen that I learn about a company project even before the employees of the firm do. Once, the Head of Product Development of a customer firm approached me with a request to develop for them a product part. The firm wanted to outsource the development of that particular part because they had too many projects on their hands. I discussed it with our Sales Manager, and we decided that we could not do it because the development would cost too much time, and would result in few sales only. By way of an alternative I suggested to the Head of Product Development that he should engage an engineering bureau for the job. The engineering bureau I recommended was a customer of ours and I was sure they could do the job. The bureau was a 'field' customer so they didn't belong to my sales territory, but I went to them and explained the problem. They agreed to develop the product part, and I advised them which product parts to use. The project was a success and the product part is now used in a car of a major car manufacturer.*

When asked by the interviewer whether the Head of Product Development also consulted the (Design) Engineers of his own firm, the Sales Engineer responded: *I don't know if he had asked anyone. Besides, I knew that his firm had cooperated with that particular* *engineering bureau before. But the Head of Product Development was new to the company and was not aware of it. I had no qualms about passing on the information because I knew that the engineering bureau was very good. I don't use my name to recommend a firm unless I am sure that they are really good.* Thus, it could be argued that the success of the project was largely due to the Sales Engineer's knowledge of the history of the customer firm.

WHY: *the NATIONAL SUBSIDIARY*
** Sales revenues. In their quest for increased turnover, the National Subsidiary prioritises their customer base according to the customer's potential to bring in increased revenues. The information relationships with customers follow a similar pattern. There are direct contacts with core customers through the visits of Sales Engineers, and there are information relationships through the development of Special Applications of product parts by Customer Solutions. The contacts and information relationships with smaller customers are entrusted to a network of Dealers.

WHY: *the REGIONAL SUBSIDIARY*
** Customer needs. The National Subsidiary prioritises customers according to their knowledge needs. The focus is on building long term relationships through which the Regional Subsidiary achieves the status of a trusted partner, someone to whom the customer would turn first for advice.

BOX 6.3

REFLECTIVE COMMENT
The prioritising of customers may lead to intensifying of information relationships, as in the case of the Regional Subsidiary. But it can also result in putting a distance between the firm and its customers, as in the case of the Dealers network of the National Subsidiary. In the context of knowledge exchange, the role of Dealers is particularly problematic. Deferring relationships with customers to Dealers deprives both Firm C and its customers from having the benefit of face-to-face exchange of information and knowledge.

SALIENT ISSUE: **Prioritising relationships in information and knowledge exchange.**

6.2.3 Supplier's (Design) Engineers/ Customer's (Design) Engineers dyad (SDE/CDE)

The focus of this dyadic information relationship is on product development carried out by Firm C for, or in cooperation with, customer firms. The product development projects often result in Special Applications. The dyadic information relationship is examined against the backdrop of the development and introduction of a new Gripper component by Firm C (to be discussed more fully in Section 6.3).

The product development projects in Firm C take place either in the Customer Solutions of Subsidiary firms (customizing and upgrading of product parts), or in the R&D division at the Headquarters (development of completely new products).

The next sections, therefore, will mirror this practice, and discuss the What's, the How's and the Why's/Why not's of the information relationships between (Design) Engineers of Firm C and customer's (Design) Engineers from the perspective of the National Subsidiary, the Regional Subsidiary and the HQ of Firm C.

WHAT: *the HQ*

** Project organization. The coordination of product development at the HQ is in the hands of the HQ Product Manager who cooperates closely with the R&D of the HQ, and liaises with Product Managers of Subsidiary firms of Firm C. The initiatives for product development come for 50 per cent from customers via the Sales Engineers of Subsidiary firms. However, in the case of the Gripper component, a major influence in starting up the project had been the very successful presentation of the product prototype at a trade show. The HQ Product Manager emphasizes that the Gripper component is not a typical example of how Firm C develops new products: *Normally, the R&D department works with Product Management, we develop a product with the product parts of Firm C, and the result is a series product that is listed in the catalogue. But with the Gripper component, the process changed 180 degrees because we first showed the product at the trade show, and now we have a push from the trade show into the company. The Gripper component is intended as a Special Application.*

WHAT: *the NATIONAL SUBSIDIARY*

** Special Applications. The division Customer Solutions did not participate in the development of the Gripper component in any way. Customer Solutions can use the Gripper component in their Special Applications only after the product had been officially released. The Product Manager of the National Subsidiary explains the reasons for the non-involvement as follows: *The division Customer Solutions was actually forbidden to get involved in the project. And you can see why. It would, of course, be very strange to do R&D at two places: the division Customers Solutions could develop something that could run counter the ideas of the HQ. The division Customer Solutions in our firm looks at novel application possibilities of standard products of Firm C. They work with the customers in this country, search for new solutions using extant products.*

WHAT: *the REGIONAL SUBSIDIARY*

** Special Applications. The division Customer Solutions did not take part in the development of the Gripper component. The relationships between Customer Solutions of the Regional Subsidiary and (Design) Engineers of customer firms, or the customer's (Design) Engineers and the R&D department at the HQ, are coordinated by the Sales Engineers. A Sales Engineer outlines the common procedure: *In cases when a customer seeks specific solutions, the colleagues from the R&D department at the HQ may take over but they keep me informed about all developments. We always try to follow the shortest route* *between the customer and Firm C, and avoid intermediaries because that leads to misunderstandings. And so far this approach worked well.*

***HOW:** the HQ*

** Project organization. The product development projects at the HQ follow a three-phase procedure. The HQ Product Manager gives an outline: *In the first phase we need to find money for the project. For the Gripper component we have a special budget, and I have one person in the R&D department assigned to the project. When that is done, the preliminary tests of prototypes can start and we learn from it. The second phase, which partly overlaps with the preliminary tests, is about the writing up of product specifications. I write down the product specifications in a book and draw up the glossary of terms. For this phase we have a Special Manager. I give him the specifications book and he consults the Gripper component with the diverse departments of Firm C. This involves more tests, producing special product parts for the pilot projects with customers, and deciding on the choice of material. At the end of this phase we have a Gripper component in three sizes (e.g., to handle kiwi, apple, and melon). The third phase leads to product release and listing in the product catalogue. The preliminary tests involved 40 pilot projects in diverse countries. I get films, pictures from the pilot projects, things I can work with.*

** Pilot projects. The information exchange during the pilot projects takes primarily place through the exchange of prototypes, personal meetings, visits to pilot customers, and a special SharePoint website. The HQ Product Manager is in charge of the website: *I place on the website all my findings regarding the project: e-mails, documents from laptops, etc. For me the SharePoint works just like a library. I am the boss and decide who gets access to it. This is the current list of people who have been given the login. I can create special access groups, some people can only read the website, and others can contribute their own texts. The system works with alerts. When someone opens the website I get an alert.* When asked about the number of people who have contributed to the website so far, the Product Manager smiles: *At the moment it's only I who is putting up the information.*

***HOW:** the NATIONAL SUBSIDIARY*

** Special Applications. When talking about the relationships between the division Customer Solutions and (Design) Engineers of customer firms, the Manager Customer Solutions mentions a core customer firm with which the division has a long history of successful product development: *There is a permanent team assigned to this particular customer firm, and fortunately, the firm keeps coming with new projects so that the team is increasing rather than decreasing in size. Normally, when the job is done, we shift our attention to another customer and to another project. We also visit customers. Our objective is that every (Design) Engineer of Customer Solutions visits customers at least forty times a year. The visits usually involve on-going projects at 10-20 customer firms. Of course, the Sales Engineer must visit the customer firms much more frequently.* It is estimated that 10-20 per cent of orders received by Customer Solutions come from customers who had approached Customer Solutions directly.

** Re-engineering reviews. A special form of information and knowledge exchange represent the so-called "re-engineering reviews". The Manager Customer Solutions explains the reviews' purpose: *We invite our customers to bring their machines here to our office and then we look together with the customer at what kind of functionality improvements could be possible. The customer keeps his design responsibility for the machine, but there may be new solutions on the market that he is not aware of. We invite each customer firm personally through the Sales Engineer. The 're-engineering reviews' take place during the Automation Days (mostly held in the afternoon or in the evening) that we organize several times per year. Each time we invite a different group of customers usually consisting of 20-30 firms, some 40-50 people. We present the latest technical developments in their industry segment, for example, packaging technology, and ask the customers whether they would be interested to start a redesign project.*

Given the fact that the participants of Automation Days are drawn from the same industry segment, it is possible that the participating firms could be each other's competitors. However, according the Manager Customer Solutions such situations have generally not been a problem: *The firms have always the choice to be present but to remain silent. That happens sometimes, or that we are requested to sign a non-disclosure agreement. But our involvement in the machines is usually limited to the level of motion and control, the 'legs and arms' of the machine, and there the concerns about competitors are less of an issue. It's quite different, of course, in cases when you develop a whole new machine in which you have a lot of sunk-in knowledge; then the customer is more reluctant to explain his needs in detail.* However, an interview with a customer firm revealed that the issue of confidentiality in information exchange still ranked high, as shown in the comment of the Director and (Design) Engineer of a customer firm: *It's good that in the case of the Gripper component, the work of (Design) Engineering and Sales were kept apart. Our firm participated in the pilot project but I would not have liked my competitor to know about it. When the product is listed in the catalogue then it's a different matter, but in the early stages of product development you expect that your trust will not be misplaced. That's why I am glad that my competitor has another Sales Engineer than I do. An accidental slip of the tongue made by a Sales Engineer is always a possibility.*

HOW: *the REGIONAL SUBSIDIARY*

** Special Applications. The relationships between the (Design) Engineers of Customer Solutions and the (Design) Engineers of customer firms occur, as a rule, at the instigation of the Sales Engineer. However, if necessary, the Sales Engineer can also invite the R&D Engineers from the HQ to examine the problem in question at the customer site. The customer firm's Director and (Design) Engineer recounts one such occasion: *At the beginning we were doing our design thinking for ourselves, and from Firm C we were just ordering product parts. But then we had a special problem with the holders in one of our machines, and for this we got in touch with the Sales Engineer of the Regional Subsidiary, and we solved the problem together.* The Sales Engineer points out that only a few parts, that were used to solve the holder problem, could actually be described as Special Applications: *We tried to use standard parts that were used in other applications but it was neither cheaper nor possible. So I invited a R&D Engineer from the HQ and we developed the product together.*

The Director comments: *Yes, that was very helpful. When we have a problem, we first look through catalogues and the Internet. But for special solutions we need a partner. We had an idea how the problem could be solved but we needed special parts to be made.*

WHY: *the HQ*

** Project organization. During the Gripper component project, Firm C enlisted customer cooperation through pilot projects. The HQ Product Manager comments: *It's really new for Firm C to have the innovation process so open. Normally, it's a closed shop; we don't share things so much, not even with universities. And Firm C doesn't have any straight forward way of dealing with this new situation. Now we have a market that is pushing and not pulling. All pilot customers must sign a waiver that they do not get any warranty on the Gripper component. We had forty pilots but at the moment I do not have a customer who would say: "I buy 30 or 40 Gripper components and incorporate them in my machine." For that the customers will need 2-3 years development time.* The Gripper component will be listed as Special Application Firm C.

WHY*: the NATIONAL SUBSIDIARY*

** Special Applications don't always need to be listed in the product catalogue. *The Manager Customer Solutions explains: Sometimes Special Applications can be included in the product catalogue particularly when the application of a product component is such that it basically leads to a new product. In that case the product concept is listed in the catalogue but the actual application is not listed because that can vary from customer to customer. We work with configuration systems. Our solutions for handling and moving objects are based on a number of basic design engineering concepts and those we keep in configuration files so that we can reuse them when necessary.*

WHY*: the REGIONAL SUBSIDIARY*

** Special Applications. In the Regional Subsidiary the initiative for Special Applications is in the hands of the Sales Engineers who, however, are the first to point out that a major part of the Regional Subsidiary's turnover actually comes from the sale of catalogue products (70-80 %). So when does a project become a Special Application? The Sales Engineer replies: *It is difficult to point out a special moment in time. A Special Application (SA) means that it is difficult for the customer to make, but it can be quite easy for someone else. Not all Special Applications get a SA number. You can make Special Applications also with standard components, only the combination is new. You offer it to the customer and he buys the components that you offer him. For the customer it is a Special Application, but the HQ does not know about it because we don't need help, and we do it as part of our offer. And there may be a few hundreds of such projects. So we make it once, but the customer can buy it several times over. However, if the customer had paid for the design then we cannot sell it to anyone else. Only in cases when a Special Application consists of standard components, can we resell it to other customers. It wouldn't be fair to co-design a product with the customer, and then sell it to his competitor, for example.*

WHY NOT *(the NATIONAL & REGIONAL SUBSIDIARY)*

** Non-involvement in NPD. The divisions of Customer Solutions at both Subsidiaries were not involved in the development of the Gripper component. It is difficult to understand why not. Customer Solutions have accumulated a wealth of knowledge through their Special Applications, and the Gripper component itself was also developed by HQ's R&D as a Special Application. A possible explanation could be that Firm C feared the repetition of communication problems encountered in the previous product development projects. The introduction of the Gripper component has not been the first time that Firm C decided to bring to market a spin-off product from its bionic design projects. A case study on the commercialization of another spin-off product (Rydell, 2010) revealed that the (Design) Engineers at the National Subsidiary were taken aback by the extraordinary amount of information sharing that the commercialization process of the new product required. The sharing of information was necessary because the new product was developed at the HQ, and the (Design) Engineers at the National Subsidiary were not familiar with all its new and complex functionalities. Consequently, the (Design) Engineers found it difficult to propose any specific new applications for the product, and the product remained on the shelf.

BOX 6.4

REFLECTIVE COMMENT

The Gripper component project represents for Firm C a new direction in product development. By introducing a prototype of the product at a trade show, Firm C first gauges whether there is enough demand for the product. When the reaction is favourable, Firm C proceeds to develop the prototype to a standard product using the feedback from the market. The large number of parties that has been involved in the development of the Gripper component (e.g., the diverse customers' pilot projects, feedback from visitors to the trade show, etc.) is reminiscent of open innovation, except that the underlying exchange of information and knowledge has been far from open. It has, in fact, been extremely fragmented: both in terms of pilot project locality, and in terms of non-commitment from the pilot's participants. The customer firms that took part in the pilot were not expected to purchase the new product once it had been released. Moreover, the knowledge exchange was mostly unidirectional: the feedback went to the HQ only, and the opportunity to share information among the project participants via a project website went unexploited. The pilot projects were seen as separate stages in the product development rather than a process of co-production of knowledge (Roux et al., 2006). The primary facilitators of the information exchange were the prototypes, and it was only there that the information exchange was bidirectional. The role of prototypes as an indispensable element in the designer's work has been highlighted by Stompff (2012) who studied multidisciplinary NPD teams.

SALIENT ISSUE: **Physical objects, such as prototypes, are information bearers during the design process.**

6.3 **The Gripper component pilot project (a case vignette)**

The Gripper component was released in three models in the spring of 2012, two years later than planned. The pilot project took place at the customer firms of the National and the Regional Subsidiary. The case vignette describe the information relationships between the (Design) Engineers of two customer firms and the Product Managers and the Sales Engineers of the Subsidiary firms at the start of the project, during the project's progress, and at the project's completion. The case vignette concludes with the researcher's Reflective Comment (Box 6.5).
For reasons of legibility, each phase in the pilot project is marked with ** and the text paragraph is indented.

** Start of the project in the National Subsidiary. The Product Manager recalls seeing the very first prototype of the Gripper component in October 2008: *The first prototype was then just a thin stalk and I said: "You should make something that can fold around an object, an apple, for example." I knew from my previous job at the fruit growing sector that there was a market for grippers that would pick up fruit without damaging it. I also knew that the gripping movement was a feature in an earlier project of bionic design project. The later prototype of the Gripper component consisted of three fingers that could fold. The advantage of the Gripper component is that it can handle products that have unusual shape, such as soft fruit. Another example is a chocolate egg which does have a regular shape but I still cannot use vacuum grippers to pick and place chocolate eggs because a vacuum gripper would suck off the foil wrapping.*

Shortly after, the Product Manager was requested by the HQ Product Manager to look among the current customer firms of the National Subsidiary for suitable candidates to participate in pilot projects. In the end there were 5 pilot projects at the national level. The Director of a customer firm that participated in the pilot recalls the project's beginning: *Our firm has been involved in the project from quite early on. Already in 2008/2009 we were getting samples of the Gripper component to test. Our participation in the pilot came about through a problem that we had with our 'sort & pick-up' machine for tulip bulbs. It was difficult to keep the bulbs in the upright position and to keep them from shifting while being picked up. We asked the National Subsidiary whether they would have a solution to that problem. It was then that we first heard about the development of a new Gripper component. The Product Manager of the National Subsidiary suggested that we tested the samples of the new Gripper component to see if the Gripper part helped solve our problem. Incidentally, we happened to know the Product Manager from his previous job when he worked for another supplier of ours. We are not a big customer of Firm C, but they probably realised that the agri-sector would have many diverse applications for the Gripper component. I had to sign a non-disclosure agreement because the patent application was still pending. We had an oral agreement that I would test the samples, report my findings to the National Subsidiary, and they would forward that information to the HQ Product Manager. Our first tests were with the tulip bulbs. Now we test the Gripper component for other tasks. For example, for the sorting and laying out cut flowers in a line on a conveyor belt, or for gathering cut flowers into a bunch. There is no fixed time frame for the tests. In our case it would not be even possible because I* *combine product development with my work as Co-Director of this firm. We have participated in pilot projects before but those projects were more about testing. The project of the Gripper component was different because it involved exchanging and sharing information.*

** Start of the project in the Regional Subsidiary. The Sales Engineer saw a prototype of the Gripper component at a trade show in 2009: *When I see a product concept coming from the bionic design projects, I first think about which of my customers could be interested, and then I tell them about it. In the case of the Gripper component I asked the HQ Product Manager to give me as many samples as possible so that I would have some samples to give away. I let the customer decide whether they could use the idea or not. The customer knows his plans for new product development better than I do. When he sees a possible application, he comes to me and asks for more information.*

One customer firm has seen reports about the Gripper component in the Magazine of Firm C and contacted the Sales Engineer about it. Together they decided to incorporate the Gripper component in the customer's agricultural machinery (built with product parts from Firm C), and test the product in real harvesting situation at the site of the customer firm's customer.

** The project's progress in the National Subsidiary. The Product Manager arranged for the HQ Product Manager to visit the pilot firms. *When showing a list of firms that participated in the pilot project, the Product Manager notes: We have started with some 7-8 firms. The firms marked 'green' are the firms that really went ahead with the tests (5 in all). The firms marked 'red', dropped out. The firms marked 'yellow' are still potentially interested but they want only a Gripper component of a particular size. We selected the firms because they belonged to our core customers: they buy practically our whole product assortment. Other selection criteria were that the customer firms worked with natural products, or products that have changing volume and shape, and that the firms wished to lead in new technology development. What's unusual about this pilot is that the Gripper component was still in an early stage of development and product modifications were possible.*

Interestingly, the Product Manager of the National Subsidiary did not get any feedback from the HQ about the pilots that were carried out in other countries, nor did he have any say in further development of the project, but it did not seem to worry him: *It is not my responsibility. I have to indicate what in my view the potential of the product is, and it's up to the HQ Product Manager to decide whether to go ahead, or stop the project.*
The pilot project resulted not only in suggestions from the customer on how to improve the Gripper component, but produced also visual documentation that Firm C used in its promotional material. The Director of the customer firm: *Most of the pictures of test installations that you now see in the product brochures of Firm C come actually from our firm, some of the photos even appeared in trade magazines. Making the photos and videos was part of our testing procedure, so that we could better demonstrate the problems that we came across. The suggestions that we made were several. For example, we suggested the use of softer material.*

The samples we received had sharp edges and damaged the stalks and leaves of cut flowers. The length of the Gripper component is also important. The pick and place movements need to be as quick as possible. With longer parts, the pick & place movement takes more time. With each suggestion we made, we received new samples of an improved product for further tests. The actual exchange of drawings, video films, photos, and product samples was always done through the Product Manager of the National Subsidiary, and the questions that the R&D at the HQ had for me also came through the National Subsidiary. When asked whether he would have liked to have direct contacts with the HQ, the Director comments: *Not really. The HQ Product Manager and two people from the HQ's R&D visited our firm, and I visited the HQ as well. I did not need any support from the National Subsidiary either because all suggestions were coming from me anyway.*

** The project's progress in the Regional Subsidiary. The customer firm of the Regional Subsidiary first tested a prototype of one of the three models of the Gripper component in a simulation environment. During the tests the Sales Engineer was the only contact person between the customer and the R&D of the HQ. The Director of Engineering of the customer firm had concrete plans for the Gripper component: *In about three weeks we shall have a machine fitted with the new Gripper component. And if we can produce a new machine that would incorporate the Gripper component, then we shall do it. But of course, the best test is to use the machine in practice, during the season, by the customer, and that will be only next year. At the moment we have an order for a Jumbo model of our agricultural machine that we have to deliver this year. The Jumbo model can work with natural products that measure 45 mm in diameter. Our normal machines can work with product with diameters ranging from 8-30 mmm. Our customers are interested in sizes in between. Since the gripper component can adjust to different diameters, we shall test the Gripper component with the Jumbo model. If successful, the older models can be fitted with the gripper component too.*

However, the tests were not successful. The Gripper component broke down after 70.000 pick and place cycles. The Sales Engineer sent the prototype back to the HQ for modification, but was still confident: *We now know what the problem is and the customer will receive a new prototype from us for further testing during the next season.* The modified prototype was, however, never tested again because the customer firm had in the meantime developed a mechanical gripping device of their own design that worked to satisfaction.

** The project completion in the National Subsidiary. The Gripper component was released in three models in the spring of 2012, two years later than originally planned. The Product Manager looks back at the project: *First we had pilot customers that already had an application for the Gripper component, and now we expect the 'followers', customers who have seen the product on the Internet, or at a trade show, and say: "I want to have that too." The pilots were successful. Everyone likes to get free samples to test, everyone likes getting presents, but what I need now is that the pilot customers incorporate the gripper component in their machines and sell it to their customers. I need a commercial success.*

At the same time, the Product Manager is skeptical about the potential sales turnover: It is only a small product component. It is only an addition to our assortment of grippers. *It is so small that I am not even allowed to include it in my MBO (management by objectives) goals. When compared with the total turnover of Firm C, or the turnover of our Subsidiary, the expected turnover from the Gripper component is peanuts. I shall be glad if the annual turnover reaches 20.000 Euros. So the question is: how much time we as an organization are going to spend on it? Given the small turnover that we expect from the Gripper component, I can spend only limited time on the product.*

The customer firm that participated in the pilot had, at the time of the interview, not yet done any high-cycle testing, but continued to test the Gripper component for extra functions. The firm was also active in seeking feedback from its customers through product presentations and talks.

The Director of the customer firm underlines the importance of customer feedback: *Our customers, the horticulture firms, know our products, and what they can do. During the presentations we introduce customers to new features and we canvass their reactions. You see that you are on the right track when the customers start thinking along with you, and suggest ideas. Product development is very important for us. We produce very few series machines, most of our products are custom designed. We don't do much outsourcing. We can accommodate customer requirements because we have all in house: design and programming, engineering, and manufacturing.*

<u>**</u> The project completion in the Regional Subsidiary. The tests of the Gripper component were not successful, the product failed to function after 70.000 pick and place cycles. The R&D of the HQ did not contact, or visit the customer firm in order to learn further details. The results of the tests were communicated to the HQ by the Sales Engineer who subsequently received from the HQ a modified prototype to pass on to the customer firm for further tests. However, the tests have not been resumed. The Director of the customer firm gives the following explanation: *Seeing is believing! If the Gripper component would help my customer through the season then I would regain my trust in the product. At the moment, I don't have that trust but am prepared to be convinced of the opposite. It is difficult to test the new prototype at the customer site because the mechanical gripper device that we have since then developed works to satisfaction. The customer does not want to have any stoppages during the harvest season, and he is therefore critical about further tests. In the end, it is the experience from practice that counts, not the glossy pamphlets and presentations.*

It is astonishing that the HQ (Design) Engineers did not contact the customer firm of the Regional Subsidiary to discover why the Gripper component broke down, and how it could be improved. After all, here was a customer who was prepared to have the Gripper component installed in his machines, something that the other firms participating in the pilots did not contemplate at the time. The customer firm's Director, an inventor with several patents to his name, would have been a valuable source of practical knowledge.

BOX 6.5

REFLECTIVE COMMENT

The innovation of the Gripper component meets the definition of disruptive technology (Christensen, 1997; Christensen and Raynor, 2003; Utterback and Acee, 2005) because it represents an incremental but radical improvement of handling objects and it broadens markets by providing new functionalities. The new functionalities, however, may initially not appeal to the core customers because they will compare the new technology with the existing applications (Bower and Christensen, 2009).

Miller et al. (2006) point out that disruptive technologies per definition do not have a market and thrive on information sharing and knowledge transfer. The information sharing during the development and introduction of the Gripper component has not been reciprocal. The exchange of information between HQ's R&D and the pilot customer firms has been mediated by the Sales Engineers and Product Managers. There has been no feedback about the pilot projects that have been held in different countries.

It is perhaps significant that the Product Manager at the National Subsidiary does not evaluate the commercialization of the Gripper component in terms of potentially new applications, but in terms of sales turnover in the established markets.

6.4 Salient Issues in the dyadic information relationships of Firm C

The Within-case Analysis of the dyadic information relationships of Firm C has resulted in the identification of three Salient Issues, namely:

In the dyad of Supplier's (Design) Engineers and Supplier's Sales Engineers (SDE/SSE), Section 6.2.1:

- Organizational forms of information and knowledge exchange (Box 6.2);

In the dyad of Supplier's Sales Engineers and Customer's (Design) Engineers (SSE/CDE), Section 6.2.2:

- Prioritising relationships in the information and knowledge exchange (Box 6.3);

In the dyad of Supplier's (Design) Engineers and Customer's (Design) Engineers (SDE/CDE), Section 6.2.3:

- Physical objects, such as prototypes, are information bearers during the design process (Box 6.4).

The Salient Issues are based on the evidence obtained through product documentation, e-mail correspondence, and interviews with nine informants. The informants represented on the one hand the functions of (Design) Engineering, Product and Project Management, Sales Management and Sales Engineers in Firm C, and on the other hand, the function of (Design) Engineering in two customer firms of Firm C. The case study evidence has been described and analysed using the Research Questions, and focused on the What's', the How's and the Why's/Why not's of dyadic information relationships.

Table 6.3 gives a summary of the analyses, with the Salient Issues listed in the last column. The Salient Issues of Firm C serve as input for a Cross-case Analysis (Chapter 8).

Table 6.3: Firm C's dyads

DYADS		DYADIC INFORMATION RELATIONSHIPS OF FIRM C			
		WHAT	HOW	WHY/WHY NOT	Salient Issues
Supplier's (Design) Engineers/ Supplier's Sales Engineers Section 6.2.1	National Subsidiary	Signalling the needs for and feasibility of developing Special Applications for the customer.	Customer differentiation follows industry segments. Sales force: industry segments & product categories. Referral & liaison relationship. Team selling. Sales Engineer as Ambassador of Firm C. Special Applications. Organizational structure. Customer database.	MBO (management by objectives) goal: increasing sales.	**Organizational forms of information and knowledge exchange. (Box 6.2).**
	Regional Subsidiary		Customer differentiation follows customer needs. Sales Engineers' capabilities . Organizational structure	Matching customer needs. Sales through relationships based on knowledge & trust. Industrial segmentation not conducive to knowledge transfer.	
Supplier's Sales Engineers/ Customer's (Design) Engineers Section 6.2.2	National Subsidiary	Contacts with customers to meet sales targets.	Visiting core customers. The Industry Segment Sales managers have coaching days with Sales Engineers. Smaller firms are referred to Dealers network.	Prioritising customer base according to potential sales revenues. Fluctuations in sales force.	**Prioritising relationships in the information and knowledge exchange. (Box 6.3)**
	Regional Subsidiary	Contacts with customers to sell knowledge.	Building long term relationships with customers. Small firms and core customers get the same amount of visits from Sales Engineers. Consultancy work by Sales Engineers.	Prioritising customers according to their needs.. Achieving the status of a trusted partner.	
Supplier's (Design) Engineers / Customer's (Design) Engineers Section 6.2.3	Headquarters (HQ)	Product Manager coordinates product development and liaises with Product Managers of subsidiary firms.	Exhibiting product concepts at trade shows, getting feedback. A three-phase product development process. Pilot projects with selected customer firms.	Showing product concepts at trade fairs results in market push.	**Physical products, such as prototypes, are information bearers during the design process. (Box 6.4)**
	National Subsidiary	Engineering (Customer Solutions) do not participate in product development(PD) of the HQ. Special Applications: Customer Solutions seek novel applications for extant product parts of Firm C.	Customer Solutions have special teams for core customers. Engineers of Customer Solutions visit core customers. Re-engineering reviews of customer's machinery. Presentation of new technologies at Automation days.	Special Applications draw on configuration files that help reuse the tried out engineering design concepts. Non-involvement in NPD.	
	Regional Subsidiary	Engineering (Customer Solutions) do not participate in fundamental product development of the HQ. Developing Special Applications for customers. .	Co-development of Special Applications with customers takes place at the instigation of Sales Engineers. Assistance of the R&D of HQ is called in, when necessary.	Special Applications represent reusable novel combination of standard product parts. Non-involvement in NPD.	

Chapter 7: **The Within-case Analysis of Firm D**

7. Introduction

The case study of Firm D is the smallest of the four case studies covered in this thesis. Firm D is a multinational tier-one supplier of naval radar and communication systems. The subject of the case study came at the suggestion of the Purchasing department of Firm D which also facilitated contacts between the researcher and the supplier firm participating in the case study. The case study concerns a joint initiative of the Purchasing department of Firm D and a preferred supplier to develop an upgrade of an air drier. The air driers supply de-humidified air to radar systems. The reasons for the upgrade were threefold:

- the increasing costs of air driers;
- the anticipated obsolescence of the air drier's compressor; and
- the desire to bring about more standardization in components that are used across diverse Product Programmes of Firm D and so achieve cost savings.

The case study informants came from the functions of (Design) Engineering (1), Purchasing (4) and suppliers' Account Management (1). The figures in brackets indicate the number of participants. Similarly, as in the analyses of Firms A, B, and C, the Within-case Analysis of firm D proceeds in two steps shown in Table 7.1.

Step 1 describes the external information relationships of Firm D arising from the firm's history, and provides the researcher's Reflective Comment (Box 7.1).

Step 2 focuses on the micro-social level of Firm D, represented by the interpersonal dyadic information relationships between the individuals working in three functional areas.

As shown in Table 7.1 and illustrated in Figure 7.1, the three dyads studied are:

- Supplier's Account Manager and Customer's (Design) Engineer (Section 7.2.1.);
- Customer's Purchasers and Customer's (Design) Engineer (Section 7.2.2); and
- Customer's Purchasers and Supplier's Account Manager (Section 7.2.3).

The analysis is guided by the Research Questions and examines the What's, the How's and the Why's/Why not's of the dyadic information relationships. A summary of the analyses is in Table 7.2 at the end of this chapter. The analysis of each dyad concludes with the identification of Salient Issues, based on the researcher's Reflective Comments about the found evidence (Boxes 7.2 – 7.4). In turn, the Salient Issues serve as input for the Cross-case Analysis in Chapter 8.

Table 7.1: Steps of analysis strategy

Step 1	External information relationships of the firm.	External information relationships of Firm D arising from the firm's history.	**Outcome:** Reflective Comment made by the researcher on the external information relationships. (Box 7.1)
Step 2	Micro-social level information relationships of the firm.	Information relationships of the dyads of Firm D: Supplier's Account Manager/ Customer's (Design) Engineer (Section 7.2.1); Customer's Purchasers/ Customer's (Design) Engineer (Section 7.2.2); Customer's Purchasers /Supplier's Account Manager (Section 7.2.3).	**Outcome:** Salient Issues in information relationships of each dyad, supported by the researcher's Reflective Comments. (Boxes 7.2 – 7.4).

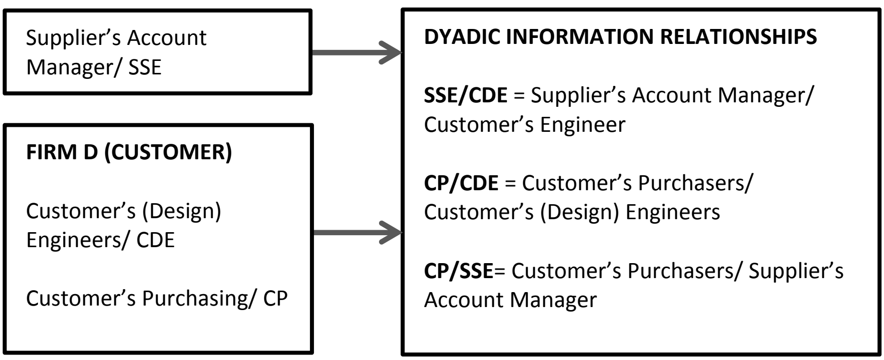

Figure 7.1 Schema of the case study of Firm D

7.1 External information relationships of Firm D arising from the firm's history

Before becoming part of a multinational corporation in 1990, Firm D was a vertically integrated company which had in-house manufacturing facilities, its own design and engineering departments, and product quality control. The scope of self-reliance is reflected in anecdotal evidence from some case study informants who report that in those days Firm D even resorted to producing their own screws because the screws on the market were too long. Comparing the past with the present, the Chief Procurement Officer notes that in former times the relationships of Firm D with suppliers were one of command and order. *We told suppliers, that they had to supply a certain product because we established that the market demanded it. Now we look at whether the supplier actually can deliver the product, and we realise that suppliers monitor market developments as much as we do. You need to have a balance between what the market demands and what the supplier can deliver. It's a push/pull story. You cannot have a relationship with the supplier without taking into account how the outcome of that relationship may affect the market. You need to make a distinction between the information which is relevant and the information which is nice to have. You need to know what other capabilities the suppliers have.* Knowing the extent to which the capabilities of suppliers and their products can accommodate the needs of Firm D is an important criterion for Firm D when selecting suppliers.

The Purchasing Product Manager cautions that: *You have to be careful that you don't ask suppliers to do something that you would like them to do, but that they themselves are incapable of delivering. Suppliers may agree to a proposition because they want to get an order from Firm D, or because they want to acquire and develop new capabilities, but when the proposition pushes them to perform above their potential, that can lead to a fiasco with suppliers.*

The manufacturability capability of suppliers can give reasons for concern, as the comment of the (Design) Engineer illustrates: *It can happen that meeting our specific requirements disrupts the supplier's production process. Our problem is solved, but it creates a big problem for the supplier in consequence. The supplier is, for example, unable to combine the manufacture of large series for his other customers with the manufacture of small series of special products for us. So long the supplier is happy to cooperate, takes pride in manufacturing a special product, things go on fine. In one case we have worked with a supplier for twenty years. Then, a new Management arrived, and we lost a supplier overnight.* The supplier's new Management had principal objections to supplying products to a Defence manufacturer such as Firm D.

Over the years the information relationships between Firm D and supplier firms have grown in importance. Four factors have contributed to this development.

Firstly, in 2008 Firm D sold the in-house manufacturing facilities for mechanical parts and assembled modules to a high-tech system supplier. The new firm remained physically located on the same site as Firm D, and acquired the status of a preferred supplier of Firm D.

Secondly, the naval radar and communication systems of Firm D began increasingly to deploy product components from ICT technology and electronics sector. Many components of these technologies are available on the market as COTS (commercial off-the-shelf) products, thus allowing for cheaper and multiple applications.

Thirdly, the generation of (Design) Engineers that exclusively relied on the expertise of Firm D was approaching retirement age. The younger generation was more open to the idea that not all product components needed to be custom-designed, and that knowledge could also be obtained outside the boundaries of Firm D. The Purchasing Product Manager sketches the new philosophy of Firm D: *You don't have to have all knowledge in-house, because there is a wealth of knowledge on the market. That means that sometime you must take money to the supplier in order to get his knowledge, whereas in former times (when Firm D was a vertically integrated company) that kind of information was so-called free.* In situations of 'early product development', Firm D may commission the supplier firm to carry out a feasibility study to explore the issues of costs and manufacturability.

Fourthly, the information relationships between Firm D and suppliers were often intertwined with trade agreements that Firm D had reached with its customers. In situations when the customer is a national government, then the trade agreement often includes offset obligations. Fulfilling offset obligations means that a substantial part of the production of Firm D's product must take place in the country of the customer. Under the offset obligations, Firm D provides extensive trainings to supplier firms in the customer's country, or commissions the original supplier firms to provide trainings in the customer's country themselves by taking part in the Transfer of Knowledge and Technology Scheme of Firm D.

BOX 7.1

REFLECTIVE COMMENT

The external information relationships of Firm D with suppliers illustrate the transition that a firm goes through when it moves away from an organizational culture pervaded by the NIH (not invented here) syndrome (Katz and Allen, 1982) to an organizational culture of a Need not be Invented Here opportunity (Hansen, 1999). The speed of this transition lies at the heart of achieving effective transfer of information and knowledge from external sources (Riege, 2005).

7.2 Micro-social level information relationships of Firm D

The present case study examines the micro-social information relationships in the context of the development of a technical upgrade of an air drier. The compressor of the air drier was getting in short supply and was expected to become obsolete in the near future. The project was a joint initiative of the Commodity Team of the Firm D's Purchasing department and the supplier of air driers.

The function of Purchasing in Firm D operates at three levels, namely:

- the level of Purchasing Product Managers (PPMs) who are responsible for purchasing budget control across all Product Programmes in Firm D. The PPMs also prepare written quotations for the customers of Product Programmes. The PPMs act as interfaces between Product Programmes and Commodity Teams: they review the costs of new product parts, delivery times, and the possible risks from the perspective of the Programme planning;
- the level of Commodity Teams of which there are twelve, and which are grouped around products that share a similar technology. The members of Commodity Teams are Purchasers and Technical Specialists. The Technical Specialists spend 20% of their working time on the Commodity Team activities. Commodity Teams have no budget. Their job is to recommend, qualify, and purchase new product parts for all Product Programmes. The purchasing costs are covered by the budgets of Product Programmes. Commodity Teams are also responsible for the life-cycle maintenance of purchased product parts;
- the level of routine Purchasers who take care of repeat orders for previously purchased product parts.

The initiative to technically upgrade a product part of the air drier that was on the verge of becoming obsolete fell therefore within the scope of Commodity Teams' work. Interesting in this case is that neither the internal customer (i.e., the Product Programme that works with air driers), nor the external customer (i.e., the Navy of a national government that purchases the Programme's products), have requested that the air drier should be technically upgraded. And yet, the financing of the upgrade project had to come from the budgets allocated to Programmes that use air driers in their products.

There are two conditions that an upgrade project must meet. The project must be 'cost-neutral', and the upgraded part must be made according to the FFF principle ('Form Fit Function'), so as not to give cause for complaint from customers. The principle of Form Fit Function holds that the upgraded product must not in any way adversely affect the structure, form, capacity, and the diverse interfaces of the product of which it forms a part. 'Cost-neutral' means that the project's funding must be contained within the existing budgets.

The case study informants represent the functions of (Design) Engineering (1), Purchasing (1 Chief Procurement Officer, 1 Purchasing Product Manager, 1 Commodity Team Leader, 1 Purchaser) of Firm D, and the function of Account Manager of the supplier firm. Together, they represent three dyads (shown in Figure 7.1), which the next paragraphs analyse in terms of the What's, the How's and the Why's/Why not's of their respective information relationships.

7.2.1 Supplier' Account Manager/ Customer's (Design) Engineer dyad (SSE/CDE)

WHAT

The supplier of air driers warns about the obsolescence of the air drier's compressor and recommends to upgrade the compressor in order to broaden the application of the air drier, and make it cheaper. The (Design) Engineer gives the technical background: *Air compressors are a difficult problem. The air drier must function 24 hours a day, 365 days a year. The air must be dry and free of dust or grease. That means that the air compressor must not be oiled or lubricated. This, however, causes greater wear and tear on the compressor's motor, and results in frequent compressor breakdowns. So, the compressor is a tricky component. There was an idea once to have air driers without compressors. This is possible in situations when the ship, or factory, has an external supply of pressured air available, so that you can bring the pressured air to the air drier. Then you don't need a compressor any more. However, you need to install an oil separator in the air drier in order to purify the air. You get a completely different drier, one that is much cheaper because the compressor is the most expensive part of the air drier. I think that the compressor represents about 50% of the air drier's total costs. The air driers without compressor are cheaper but they can be used only in locations where there is an external supply of pressured air and that supply needs to be permanently available. So, the air driers are expensive products but without alternatives to replace them. The Product Programmes always complain about the costs air driers.*

The Supplier's Account Manager justifies the need for the upgrading of the air drier as follows: *Every time a product part in an air drier became obsolete, we had to find a FFF (Form Fit Function) alternative for it. For each air drier we sell, we have an obligation to supply spare parts for 15 years. So the longer you wait with checking all product parts for obsolescence, the greater the legacy of product obsolescence will be. Of course, you can always find solutions for replacing an obsolete product part. But, it costs money; it costs engineering, because you need to make design modifications. So tackling these problems in one go, by designing a new drier, makes things a lot easier for us. That's why we are prepared to offer such a new air drier at a lower price.*

HOW

The exchange of information and knowledge between the (Design) Engineers and the supplier firm primarily relates to functionality issues. The (Design) Engineers provide knowledge about "the surroundings" in which the product part must function, whereas the supplier firm provides knowledge about the conditions under which the product part can function.

The upgrading of the air drier consisted of placing an air reduction & filter unit inside the new model, whereas in the old model the unit was external. Thus, the new air drier had a broader application because it could also function in environments that have secure supply of external pressured air. In such locations, the air filter can alternate with the compressor and therefore can extend the compressor's life expectancy. According to the Supplier's Account Manager, the life expectancy of compressors is ten years, under normal maintenance conditions. The costs reduction involved replacing the military specification motor of the air compressor with a COTS (commercial off- the- shelf) alternative, qualifying the compressor, and making it FFF (form fit function) compliant.

The exchange of information and knowledge between (Design) Engineers and supplier firms can also take place informally, at trade shows. The (Design) Engineer praises the trade shows of the aircraft industry: *Many suppliers that participate, for example, in the Farnborough Airshow are small firms of 200-400 employees, but they are used to supplying 'non-standard' products or 'specials', and therefore understand our needs. They are aware of the importance of weight in the choice of materials, and they have good delivery reliability. In contrast, if we show our product specifications to industrial manufacturers, we get to hear "This is too difficult for us", or they may think that they could produce the product, and we discover only later that they did not fully understand the specifications.* In the (Design) Engineer's view, an alternative to 'specials' is to use COTS (commercial off- the-shelf) products that Firm D purchases, and subsequently makes compliant with the requirements of Firm D, and those of the customer. *You can certainly reduce the costs that way. However, it is important to have the product documentation in order. The supplier of a COTS product gives a guarantee, but if you make the product compliant with your own specifications, the guarantee no longer applies. So you have to document the specifications of the product at the point of purchase, and then add to it your own document with details about the changes that you have made and the qualification tests. The result is a new product with a new product number.* Having a COTS alternative for an air compressor was at the heart of the technical upgrade of the air drier. The result was a new air drier with a new product number.

WHY

Reducing production costs makes the products of Firm D more competitive. Since the specific knowledge of product parts and their substitutes resides with supplier firms, the first step in a proactive costs reduction policy requires anticipating, monitoring, and responding to signals from suppliers. The technical upgrade project of the air drier is an example of how a Commodity Team of Firm D responded to a signal from a preferred supplier. The signal prompted the Commodity Team to counteract the anticipated future costs of product obsolescence by requesting the supplier firm to propose a FFF (Form Fit Function) alternative.

WHY NOT

The (Design) Engineer cautions that there are limitations to what supplier firms can contribute in terms of knowledge: *suppliers have knowledge about how to manufacture a certain product, and they build on that knowledge, and develop it further, but they cannot help you with material strength analysis, for example.* The (Design) Engineer attributes the limited possibilities in which the suppliers can contribute knowledge to NPD to the vast amount of knowledge and expertise that exists within Firm D: *We are an organization that has many well-educated and highly skilled specialists who can be deployed across diverse projects, so that on the whole, there is more knowledge within Firm D than there is at the supplier firms.* However, the (Design) Engineer makes an exception for preferred suppliers from whom he expects that: *They must be prepared to share their knowledge, and the same applies to* *us, so that together, we bring our knowledge to a new level. I suspect that you are more likely to get that kind of relationship with a single source supplier because then the supplier has the certainty that he gets the order.*

On the issue of dual sourcing the (Design) Engineer explains why having two suppliers is not always possible: *Of course, it would be good to have a second source for a number of product parts. But that means that you would have to order the product parts from both suppliers. If you don't do that then you cannot expect any cooperation from suppliers because of the small volume that we purchase, and the manufacturing costs involved. The suppliers want commitment. For us, as manufacturers of small volume special products, dual sourcing is not always an option. I believe our firm has a long list of product parts for which we have only one supplier, often this is because there are no other suppliers to be had.*

BOX 7.2

REFLECTIVE COMMENT

The selection of suppliers in Firm D is governed by several considerations. One is the high-tech character of products and the small volume in which Firm D produces them. In order to differentiate the products of Firm D from those of competitors, Firm D needs suppliers with capabilities that add extra functionalities to product parts, or that are able to adjust standard products to diverse application settings in which products of Firm D operate. Taken together, these factors often result in Firm D having to work with sole/single source suppliers. Another consideration is that the customers of Firm D are mostly Defence organizations from all over the world. This fact brings in political issues: foreign suppliers, for example, may be subject to export restrictions.

SALIENT ISSUE: **Single Sourcing and information and knowledge exchange.**

7.2.2 Customer's Purchasers/ Customer's (Design) Engineer dyad (CP/CDE)

WHAT

The upgrade project of the air drier took place in the period November 2003/November 2004. The project fitted well in the policy that Firm D at that time had introduced, namely to reduce the production costs by 40%. The project was initiated by the Commodity Team.

HOW

Given the fact that the Commodity Teams have no budget of their own, any costs saving activity that a Commodity Team may initiate, is subject to approval by the Product Programmes. The approval procedure and the exchange of information that goes with it take the form of a business case that the Commodity Team Leader submits to the Programme Manager.

The Commodity Team Leader describes the writing up of a business case as an iterative process. *When you receive signals about potential product obsolescence, you first discuss it in the Commodity Team and explore whether there is enough ground for a business case. The writing up of a business case requires several iterations before it reaches maturity. You have to talk to the stakeholders such as the Purchasing Product Manager and the Programme Manager. Since air driers are deployed in diverse Programmes, the writing up of the business case involved a great deal of lobbying about costs sharing. The Technical Specialists had to validate the information that we received from the supplier firm, and formulate the implications of product substitution for Firm D. Are product parts of air driers really getting obsolete? Can we get a COTS (commercial off-the-shelf) substitute? Would the COTS substitute be compatible with the FFF principle ('Form Fit Function')? In the end, the business case must convince the Programme Managers that the substitution of the product part is feasible technically and financially, and within a given timescale. There was also a fall-back scenario in case that the new product part would not be qualified in time, but we did not have to use it.*

The Purchasing Product Manager recalls that the difficulty of the air drier upgrade project lay in its complexity: *The technical upgrade of air drier potentially concerned three Programmes, and of course, each Programme guards its own budget. The practice in our firm is that the funding of projects such as this must come from the accrued savings of a particular Programme. But the savings will materialize only when the product gets sold. So we try to pair off such projects with a current order. And at that time, there was one Programme that received an order for ten air driers from a national government. In the first instance, the Manager of that Programme was not enthusiastic about the technical upgrade project because he saw only costs and no benefits. That was, of course, short-term thinking. The long-term thinking is: "If you don't do it now, then you will never do it, and you will have a problem in the long run." Besides, I could show the Programme Manager that the project would end with a positive balance. Moreover, the Commodity Team Leader managed to persuade the two other Programme Managers to share in the costs of the upgrade, and then everyone was happy.*

WHY

The information relationship between (Design) Engineering of the Product Programmes and the Commodity Team of the Purchasing department can be described as that of a customer and a service provider. The Purchasing Product Manager points out that: *The service of Purchasing lies in suggesting better alternatives for product parts and in backing the suggestions up with solid argumentation. The reason why the Programme Manager was at first not convinced about the need for an upgrade was because of the way the cost estimations were initially presented to him.* However, the reasons why the exchange of information and knowledge between Purchasers and (Design) Engineers is not always optimal may also lie in the misconceptions about what Purchasers actually do, or could be doing.

WHY NOT

The Commodity Team Manager points out some common misconceptions about the function of Purchasing. The Purchaser is often perceived as someone who only drafts and negotiates contracts, but the Purchaser does more than that: *The Purchaser attends trade shows and brings back information, brochures and photos. Purchasers have a wide network of contacts: they know whom to approach for appropriate information. Since the Commodity Teams are organized along shared technologies, they have an overarching knowledge of content areas of diverse Product Programmes. The project teams of Product Programmes, on the other hand, are temporary and do not guarantee strong relationships among team members. The teams get disbanded once the project ends, and it is only after people have worked together three or more times that they start sharing information.*

In the view of the Commodity Team Leader the exchange of information and knowledge between (Design) Engineering and Purchasing is hindered by lack of technical education among Purchasers: *It is surprising how many function profiles there exist when you look at job advertisements. It would seem that organizations do not quite know where to place Purchasing in their organizational structure. Often, the advertisements focus only on the operational tasks, but the overall responsibility for Purchasing is placed upon Management. As recently as few years ago job descriptions demanded higher technical education. Nowadays having 'affinity' with technology is sufficient.*

The (Design) Engineer underlines the role of connections at interpersonal levels: *Personally, I think that the functioning of an organization is based on relationships rather than on a formal structure. You seek advice from someone whom you know. You don't stop to think that there could be official channels for contacting people.* The Purchaser holds a similar view: *The strong ties require work. It takes sometimes 5-6 years to create a solid team, it is a group process. When the strong ties are not there one has to do with weak ties. The ties are informal and diverge from the official organization structure. One knows whom to contact.*

Another issue of contention between the (Design) Engineers and the Commodity Team concerns the single point of contact. The (Design) Engineers sometime enter into agreements with supplier firms without prior notification to the Commodity Team. This practice, however, is according to the Purchasing Product Manager on the decrease. *The (Design) Engineers, of course, know the supplier firms from the market, or from the Internet. They see a certain product function, but cannot find the additional information they need in product catalogues. They contact the supplier firm to ask about the structure of the product, and whether the supplier firm also makes 'specials'. But the product needs to be designed first, and the knowledge about the product parts and their suppliers resides with the Commodity Team. What the (Design) Engineers sometimes forget is that each purchase comes with a whole purchasing infrastructure. Therefore, it is very important for Purchasing to have a good relationship with internal customers. As a Purchaser you have to operate in such a way that the (Design) Engineers turn to you for help rather than contact suppliers themselves. You have to build up the credit with your internal customer, and then they come to you of their own accord.*

The Commodity Team Leader provides a different explanation for the (Design) Engineers' behaviour: *The products of Firm D are currently under price pressure. In identifying the cost drivers of their products, the (Design) Engineers look at product parts. The Programmes may, for example, decide to commission the Commodity Team to identify opportunities for costs reduction. Such projects involve the working hours of members of the Commodity Team: the Purchaser and the*

Technical Specialist. But whereas the time of the Purchaser is 'free' (i.e., viewed from the perspective of the Product Programmes), the working hours of the Technical Specialist are charged against the Programmes' budgets. What then happens is that the Programme (Design) Engineers reckon that it is cheaper if they make inquiries themselves rather than hire the Technical Specialist of the Commodity Team.

However, the Commodity Team Leader shares the view of the Purchasing Product Manager with regard to the function of Purchasing in Firm D, and the need for flexibility. *Of course, the Commodity Team can acquire this image of a strong referee or a high priest, someone who tells people how the purchasing works. However, in practice it is different. You have to make allowances, give room to the Programme (Design) Engineers to ask the supplier firm: "How much would it cost if we were to do it this way?" And afterwards, the (Design) Engineers come to us and we formalize the agreements with supplier firms together. You have to show some flexibility otherwise you cannot operate as a company.*

BOX 7.3

REFLECTIVE COMMENT

The initiation and implementation of the upgrade project depended as much on the strength of information relationships between Purchasing and Product Programmes as it did on the strength of the argument itself. The principle of 'Form Fit Function' that Firm D applies to its products is equally applicable to the exchange of information and knowledge. For example, it could be argued that the reason why the Purchasing Product Manager (PPM) was more successful in justifying the costs of the technical upgrade project to the Programme Manager than the initial proposal of the Commodity Team was because the PPM knew from his experience as Programme Budget Controller how best to format the presentation of the cost estimations to fit the function of the Product Programme. Similarly, the exchange of information and knowledge between Purchasing and (Design) Engineering is governed by the presence/absence of information relationship between the individuals working in the two functions.

SALIENT ISSUE: **Relational properties of the information and knowledge exchange.**

7.2.3 Customer's Purchasers /Supplier's Account Manager dyad (CP/SSE)

<u>WHAT</u>

The supplier firm that co-initiated the technical upgrade of air drier has been the sole and preferred supplier of air driers to Firm D for thirty years. The Supplier's Account Manager describes what his firm understands under the term 'preferred supplier'. *We expect to be the first one to be asked when the customer looks for a technical solution, or a new product. Our policy is to supply total solutions to customers, not just products. We are open to customer suggestions. In the case of the air drier project the initiative was 50/50.*

The Supplier's Account Manager remembers the beginning of the project as follows: *The Technical Specialist of the Commodity Team, our Technical Specialist and I have discussed air driers many times in the past, but nothing ever came out of it. We talked about how we could make the air driers simpler, smarter, and standardized. Many product parts were getting in short supply or were becoming obsolete. We have an obligation towards Firm D to supply product parts that are always FFF (fit form function) compliant, but finding alternatives for FFF product parts requires extra effort. That's why we wanted to review the air drier in its entirety. However, the project itself started much later, in 2003. Firm D requested us to look at the specifications of the old model and to come with a proposal on how to make the air drier smarter by integrating new components. And of course, the new air drier had to be cheaper. Firm D set the costs saving target at 40%, but the ultimate costs reduction that we managed to achieve was around 25%.*

HOW

The Commodity Team Leader recalls the beginning of the project: *During a regular meeting with the supplier of our air driers, the Supplier's Account Manager informed us that the delivery time of compressors used in the air driers was getting longer, and that the compressors were also becoming obsolete. The Technical Specialist of the Commodity Team then came with a suggestion to design a new air drier. The technology of the old model stemmed from the 1970's, and that meant that you had to bring the air drier to a whole new level.* In reaction to an interviewer's question why Firm D did not look for another (i.e., second) supplier instead, the Commodity Team Leader comments: *In this particular case we wanted to have the benefit of the expertise of the supplier. This supplier firm also delivers compressors to the civil market, and has therefore a good overview of technologies available. And another advantage is that the suppler firm is local, that is operates in this country, which makes cooperation easier.*

The costs reduction involved replacing the military specification motor of the air compressor with a COTS (commercial off-the-shelf) alternative, qualifying the compressor, and making it FFF (form fit function) compliant. The financing of the project came primarily from the budget of a Programme that received an order for ten air driers from a national government.

The exchange of information between the Commodity Team of Firm D and the supplier firm started with a redefinition of the build-to-print specifications that the Commodity Team already had for the extant air drier. The Technical Specialist of the Commodity Team then submitted the new functional specifications to the supplier firm. The Commodity Team Leader explains what the redefinition entails: *What you in fact do is that you make the specifications less prescriptive. Providing broader specifications allows for greater input from the supplier. You create a kind of 'black box' and ask the supplier to come with suggestions on what the black box should contain.* The supplier firm responded to the new functional specifications by submitting an Engineering Change Proposal supported with drawings and test results.

The next step in the procedure is the review of the proposal by the Commodity Team which can request additional tests when necessary.

The qualification tests take place at the site of Firm D to which the supplier firm gets invited as an observer. The final approval of the new product is in the hands of Firm D. If the qualification tests fail, the whole process begins anew.

In this case, ten pieces of the new air drier, with a new product number, were delivered to the customer, a national government, but were returned by the customer as defective. The customer demanded that the COTS compressors in the air drier be replaced by compressors containing a military specification motor.

WHY

The Supplier's Account Manager explains what had happened: *The air driers broke down because they were installed in navy ships that were still under construction in a commercial shipyard, and the environment in the shipyard was not dust-free. In fact, when the air driers came back we found small pieces of metal shavings inside. When the same air driers were supplied to a customer of another Programme, they functioned without problems. However, there was a perception on the part of the customer, and also on the part of some (Design) Engineers in Firm D, that had the air drier been equipped with compressors containing a military specification motor and not with COTS (commercial off-the-shelf) compressors; the air drier would not have broken down. However, Firm D had still another problem. The customer refused to pay not only for the air driers but also for the whole system of which the air driers were a part, and that amounted to loss of millions of dollars. For our part, we did not feel responsible for the breakdown of air driers because the customer did not follow the installation and operating instructions. However, we assumed our responsibility towards Firm D: we took all ten air driers back and substituted the COTS compressors with compressors that had a military specification motor, and we never heard from the customer again. However, the substitution of compressors required design modifications because the new model, unlike the old one, had an integrated air filter unit that took up space. Firm D, being aware of the risk of customer's delayed payment, was prepared to bear the costs of design modifications.*

The Commodity Team Leader comments: *It was in those days a trend to change over to COTS product parts as much as possible in order to reduce production costs. The risk for us, operating in the Defence industry, is that COTS products do not meet the specifications that our customers require. The COTS products do not comply with military specifications and that means that we have to qualify the product ourselves. In this case, we have proposed to the customer a new model of air drier that was FFF compliant and came at a reduced price. A price reduction is always interesting for the customer.*

The Purchasing Product Manager notes that: *In principle I am in favour of using COTS products, but I have learned from experience that COTS products are only of limited use to us. They always need to be improved one way or another because we want to have something extra to offer to our customers.*

WHY NOT

The Supplier's Account Manager reflects on the fact that the military specification products are often indistinguishable from their COTS counterparts: *We apply COTS products in air driers for the civil market. I believe this was one of the first times that we proposed a*

COTS product to Firm D. However, a supplier firm cannot introduce a COTS product unless it had reached a prior agreement with the customer, in this case, with Firm D.

BOX 7.4

REFLECTIVE COMMENT

There were no recriminations between the Commodity Team of Firm D and the Supplier's Account Manager about who was to blame for the customer's complaint. Instead, both parties cooperated in finding a solution to the problem. The supplier firm, in the words of the Supplier's Account Manager 'assumed its responsibility' towards Firm D. However, operationalizing that responsibility meant that the two firms had to draw heavily on the strength of social relationships at the interpersonal level, and on mutual trust in each other's expertise. Presumably, had the social relationship and the personal interaction between the representatives of the two firms been less strong, the handling of the customer's complaint would have taken a different course (Mainela and Ulkuniemi, 2009; Granovetter, 1973, 1982). Case studies (Melander and Lakemond, 2012) have shown that when problems occur in NPD projects, Purchasers, because of their special relationships with supplier firms, are often called upon to act as trouble shooters.

SALIENT ISSUE: **The role of social ties in troubleshooting events between customer and supplier firms.**

7.3 Salient Issues in the dyadic information relationships of Firm D.

The Within-case Analysis of the three functional dyads in Firm D resulted in the identification of the following Salient Issues:

In the dyad of Supplier's Account Manager and Customer' s (Design) Engineer (SSE/CDE), Section 7.2.1:

- Single Sourcing and information and knowledge exchange (Box 7.2);

In the dyad of Customer's Purchasers and Customer's (Design) Engineer dyad (CP/CDE), Section 7.2.2:

- Relational properties of information and knowledge exchange (Box 7.3).

In the dyad of Customer's Purchasers and Supplier's Account Manager (CP/SSE), Section 7.2.3:

- The role of social ties in troubleshooting events between customer and supplier firms (Box 7.4).

The Salient Issues are based on the evidence obtained through product documentation, e-mails, and interviews with six informants representing the functions of (Design) Engineering and Purchasing in Firm D, and the function of Account Manager in the supplier firm. The case evidence has been described and analysed following the three Research Questions relating to the What's, the How's, and the Why's/Why not's of dyadic information relationship. A summary of the analysis is in Table 7.2. The Salient Issues of Firm D serve as input for the Cross-case Analysis (Chapter 8).

Table 7.2: Firm D's dyads

DYADS	DYADIC INFORMATION RELATIONSHIPS OF FIRM D			
	WHAT	HOW	WHY/WHY NOT	Salient Issues
Supplier's Account Manager/ Customer's (Design) Engineer Section 7.2.1	The supplier warns about the obsolescence air drier's compressor to make it cheaper and to broaden its application.	Addressing the functionality issues: system design versus component design. COTS products (commercial off-the-shelf). FFF (form fit function) compliance Attending Trade Fairs for 'non-standard' products or 'specials'. .	Pro-active costs reduction policy to increase competitive advantage. Limitations of supplier knowledge. Knowledge sharing with preferred suppliers. Dual sourcing is not always an option.	**Single Sourcing and information and knowledge exchange. (Box 7.2)**
Customer's Purchasers/ Customer's (Design) Engineer Section 7.2.2	Commodity Team strives to reduce production costs of air drier's compressor by 40%. .	Commodity Team Leader writes up a business case for the (Design) Engineers of Product Programmes. Pros and cons of COTS products Lobbying about cost sharing across diverse Product Programmes.	The relationship between the Commodity Teams and the (Design) Engineers is that of a service provider and an internal customer.. Misconceptions about the function of Purchaser. Lack of technical education among Purchasers. The importance of interpersonal relations.	**Relational properties of the information and knowledge exchange. (Box 7.3).**
Customer's Purchasers/ Supplier's Account Manager Section 7.2.3	Joint initiative to technically upgrade air driers. Air drier's compressor is getting in short supply and obsolete. Introducing air dries without compressors. The upgrade project must adhere to FFF (form fit function) principle.	Replacing a military specification compressor by a COTS (commercial off- the-shelf) alternative. The Commodity Team redefines air drier functional specifications. The supplier submits an Engineering Change Proposal. Qualification tests. Target savings: 40%. Achieved savings: 25%.	The air driers break down at the customer site. Customer did not follow the installation instructions. The customer demands that COTS compressors be replaced by military specification compressors. The supplier firm 'assumes its responsibility' towards Firm D. The supplier and Firm D jointly solve the problem.	**The role of social ties in troubleshooting events between customer and supplier firms. (Box 7.4)**

Chapter 8: **The Cross-case Analysis**

8. Cross-case Analysis: starting with four building blocks

The Cross-case Analysis is a method that aims to identify and scrutinize the commonalities and differences across cases on the basis of an earlier developed conceptual framework. The aim of the identification and analysis of commonalities and differences is to learn from the different contexts of the different cases. Thus, the cross-case Analysis aims for the detection of patterns of covariation among the cases and look for correspondence. According to Stake (2006: 28):

> *Correspondence means patterns of covariation. It is correlation. It means that things are happening together. When we experience repetitious correspondence, we usually think we understand some of the 'interactivity' of the case – that is, some ways in which the activity of the case interacts with its contexts.*

The procedure of a Cross-case Analysis, followed in the present thesis, rests on four major building blocks. In the following, these building blocks are described chronologically as they were adopted.

- Building block 1: The Research Questions have been derived from the gaps found in the literature review (Chapter 2):
  RQ1: *What does constitute an information relationship between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineers of supplier and customer firms during the fuzzy front end (FFE) of new product development (NPD)? What type of information and knowledge is exchanged?*
  RQ2: *How does an information relationship between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineers of supplier firms and customer firms work? How does the exchange of information and knowledge take place?*
  RQ3: *Why do some information relationships between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineers of supplier and customer firms lead to the utilization of supplier information and knowledge, and other do not?*

- <u>Building Block 2:</u> The Conceptual Framework, shown in Figure 3.3 (Chapter 3) has been informed by research into the role of social ties in the exchange of information and knowledge (e.g., Borgatti and Cross, 2003; Cross and Sproull, 2004; Granovetter, 1973, 1982, 1985; Hansen, 1999; Hansen et al., 2001; Levin and Cross, 2004; Rodan and Galunic, 2004; Uzzi, 1996, 1997).
  The basic premise of the Conceptual Framework is that the utilization of supplier information and knowledge in the FFE of NPD is an outcome of a continuous dynamic information and knowledge exchange process that takes place within the information relationship between the sender and the provider, and is enabled by social ties. The sender and the provider form a dyad. The Conceptual Framework posits that the type of social tie (i.e., strong tie, weak tie, or trusted weak tie) in the dyadic information relationship helps explain the What's, the How's, and the Why's/Why not's of the information relationships in relation to the utilization of supplier information and knowledge in the FFE of NPD. In the present thesis, the dyadic information relationships involve the individuals working in three functional areas of the focal firms, and their respective suppliers and customers. The functional areas are: (Design) Engineering, Purchasing and Sales Engineering. – The term 'focal firm' is used to describe the four participating firms. The term is used intentionally in order to differentiate between situations when the focal firm acts as supplier (i.e., interacting with its customers) as opposed to when the focal firm acts as customer (i.e., interacting with its suppliers). The implication of this dual role of the focal firm is that the utilization of supplier information and knowledge takes place either at the focal firm, in which case the source of supplier information and knowledge are the focal firm's suppliers. Or, the utilization takes place at the focal firm's customers, in which case the source of supplier information and knowledge is the focal firm.

- <u>Building block 3:</u> The data analysis, the first round of which consisted of coding and categorising 42 verbatim transcripts of interviews and field notes collected in the course of the investigation (described in detail in Chapter 3). The coding and categorising resulted in a statement which, when coached in the terms of the identified central categories, captures the essence of the case study. According to Strauss and Corbin (1998: 146), a good test for the validity of central categories is whether it is possible to explain in one sentence what the research is about. This is shown in the statement below in which the central categories that emerged from the coding and categorising of data are underlined.

  > *<u>Beliefs</u> about <u>the potential of suppliers</u> are an underlying factor in <u>the information environment</u> in which the <u>functional area staff</u> of customer and supplier firms meet and collaborate in the course of NPD.*

Interpreting this statement in the light of the Research Questions, a conjecture can be drawn that the utilization of supplier information and knowledge in the FFE of NPD will be influenced by whether or not the information environment in which the functional area staff work is conducive to the functional staff's belief in the capabilities of supplier firms.

- Building block 4: The Salient Issues resulting from the Within-case Analyses of the four focal firms, and described in detail in the respective case reports (Chapters 4-7).
  The Within-case Analyses represent the second round of data analysis. The analyses were guided by the Research Questions and focused on the What's, the How's, and the Why's/Why not's of the dyadic information relationships in relation to the utilization of supplier information and knowledge, as set out in the Conceptual Framework (Figure 3.3 in Chapter 3).
  Each of the four Within-case Analyses concludes with several Salient Issues, identified by the researcher. In all, the Within-case Analyses resulted in 22 Salient Issues shown in Table 8.1. The Salient Issues typify the dyadic relationships between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering in relation to the utilization of supplier information and knowledge in the FFE of NPD.
  In the case reports, the choice of the Salient Issues is preceded by the researcher's Reflective Comments. A Reflective Comment represents a first tentative assertion (observation) about the evidence from which the Salient Issue emerged. Of the 22 Salient Issues identified, 16 Salient Issues can be said to be cross-cutting, meaning that they pertain to more than one case, and/or can be found in more than one dyadic information relationship. The list of cross-cutting themes is shown in Table 8.2.

8.1 From cases to universality: the cross-case study structure

The adopted Cross-case Analysis procedure and method draw on the book Multiple Case Study Analysis by Robert E. Stake (2006), and on the analytic technique of 'explanation building' (Yin, 2003: 120). The technique of explanation building, as applied in the present thesis, involves comparing, revising, and iterating the case evidence, captured in Salient Issues and Reflective Comments, until an explanation of the studied phenomenon (i.e., the utilization of supplier information and knowledge) is reached.

Figure 8.1 outlines the five consecutive stages of the Cross-case Analysis, and shows the linkage between the structure of the Cross-case Analysis and the structure of the preceding Within-case Analyses.

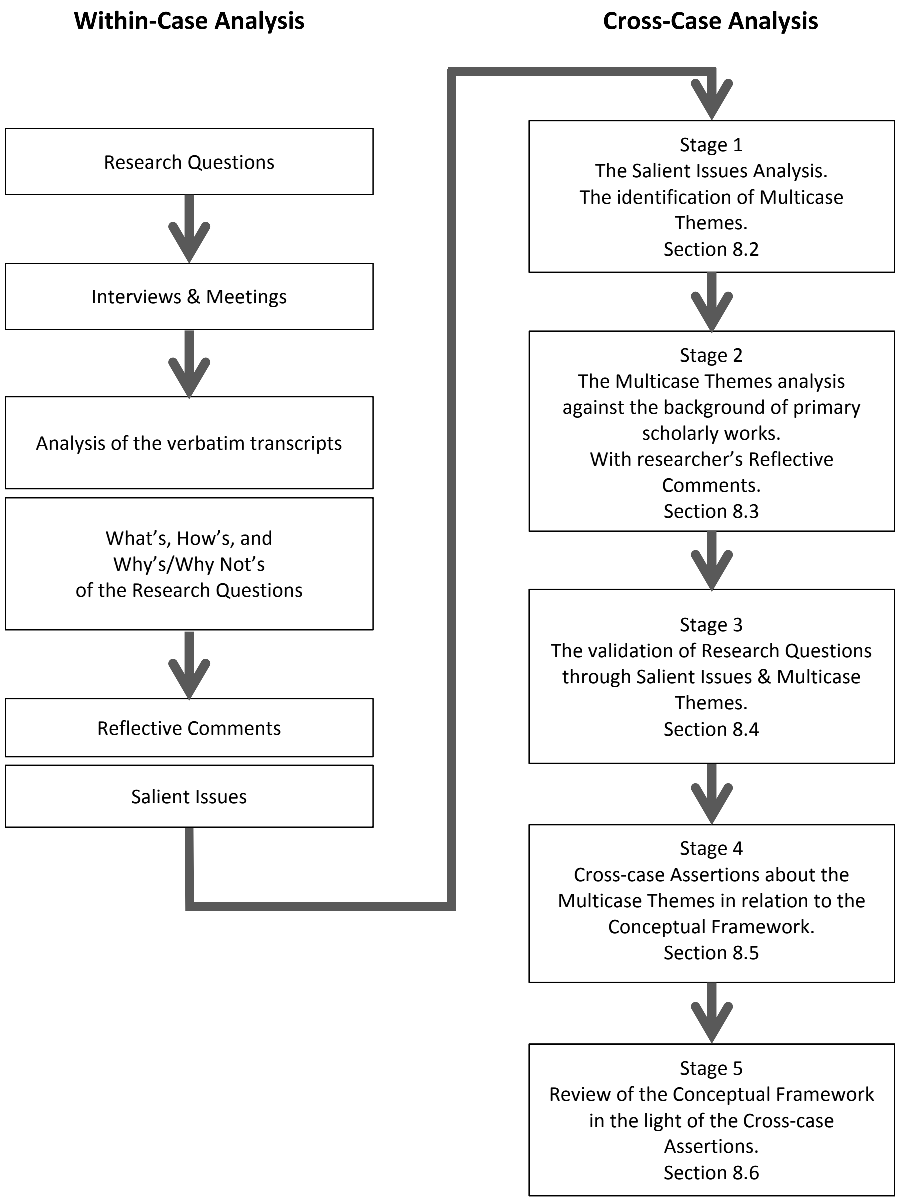

Figure 8.1 Structure and procedure of the Cross-case Analysis and the preceding Within-case Analyses.

The Cross-case Analysis proceeds in five consecutive stages.

- The first stage (Section 8.2) focuses the analysis of Salient Issues. It seeks to establish the universality of the Salient Issues across the four cases (For example: When a Salient Issue occurs only in one single case, does it mean that the particular single Salient Issue bears no relevance to the other cases?). The first stage concludes with the identification of four Multicase Themes;
- The second stage (Section 8.3) proceeds to analyse the Multicase Themes. Each Multicase Theme is analysed against the background of primary scholarly work in order to establish the Multicase Theme's credibility. The second stage concludes with the researcher's Reflective Comments;
- The third stage (Section 8.4) deploys the Salient Issues and the Multicase Themes to validate the Research Questions;
- The fourth stage (Section 8.5) formulates the Cross-case Assertions about the Multicase Themes in relation to the Conceptual Framework (Figure 3.3 in Chapter 3) to examine the fit between the Conceptual Framework and the evidence captured in the Multicase Themes;
- The fifth stage (Section 8.6) reviews the Conceptual Framework in the light of the Cross-case Assertions.

8.2 ***Stage One:*** **The analysis of Salient Issues**

The cross case analysis begins with the examination of Salient Issues.

Table 8.1 provides an overview of the 22 Salient Issues together with the firms and the Reflective Comments (Box numbers) from which the Salient Issues originate. As explained in Chapter 3, the term 'salient' means prominent rather than important. It designates the degree to which an aspect of a dyadic information relationship is uppermost in the minds of informants, that is, emerged as such from the interviews (after Mellon, 2011). The selection of Salient Issues is not free of the researcher's bias. The fact that the researcher has singled out a particular piece of evidence as a Salient Issue, reflects the compound influence of the Conceptual Framework, the Research Questions, and the coding and categorising of the verbatim transcripts.

Table 8.2 shows that 16 of the 22 Salient Issues are cross-cutting, meaning that these Salient Issues have overlapping content, and were found in more than one firm. The overlapping occurrence of cross-cutting Salient Issues is shown in the column 'Corresponding Salient Issues'. The 16 cross-cutting Salient Issues were subsequently subsumed into three Multicase Themes, shown in Table 8.3. The working names of the Multicase Themes and the Sections in which they will be discussed further are:

- Social Ties (Section 8.3.1);
- Single Sourcing (Section 8.3.2), and
- Physical Objects (Section 8.3.4).

Table 8.1 The Salient Issues with the firms and Reflective Comments (Boxes) from which they originate.

Salient Issue (SI) number	Salient Issues	Firms
SI 1	Information & knowledge exchange through social ties.	Firm A, Box 4.4
SI 2	Knowledge properties of social ties.	Firm A, Box 4.5
SI 3	Sole sourcing and information and knowledge exchange.	Firm A, Box 4.6
SI 4	The role of trust in information and knowledge exchange.	Firm A, Box 4.7
SI 5	The strength of social ties.	Firm A, Box 4.8
SI 6	The exchange of information and knowledge as business courtship.	Firm A, Box 4.9
SI 7	The supplier's Sales Engineer as a social mediator between his/her firm and the customer's (Design) Engineers.	Firm A, Box 4.10
SI 8	Single Sourcing and information & knowledge exchange.	Firm A, Box 4.11
SI 9	The negotiating value of information and knowledge.	Firm A, Box 4.12
SI 10	Preferred suppliers as a source of information and knowledge.	Firm A, Box 4.13
SI 11	Physical objects are information bearers in the conceptual design stage.	Firm B, Box 5.3
SI 12	The strength of social ties' role in the valuation of information and knowledge exchange.	Firm B, Box 5.4
SI 13	The role of Single Sourcing and Preferred Suppliers in the context of information and knowledge exchange.	Firm B, Box 5.4
SI 14	Audits and Supplier Development as mechanisms for the exchange of information and knowledge.	Firm B, Box 5.5
SI 15	Engineering educational background of Purchasing staff.	Firm B, Box 5.6
SI 16	The relational assets of Single Sourcing.	Firm B, Box 5.7
SI 17	Organizational forms of information and knowledge exchange.	Firm C, Box 6.2
SI 18	Prioritising relationships in the information and knowledge exchange.	Firm C, Box 6.3
SI 19	Physical products, such as prototypes, are information bearers during the design process.	Firm C, Box 6.4
SI 20	Single Sourcing and information and knowledge exchange.	Firm D, Box 7.2
SI 21	Relational properties of the information and knowledge exchange.	Firm D, Box 7.3
SI 22	The role of social ties in troubleshooting events between customer and supplier firms.	Firm D, Box 7.4

Table 8.2 Identification of cross-cutting Salient Issues

Salient issues (SI)	**Corresponding Salient Issues**
SI 1 Information & knowledge exchange through social ties.	SI 2, SI 5, SI 6, SI 7, SI 12, SI 18, SI 21, SI 22.
SI 2 Knowledge properties of social ties.	SI 1, SI 5, SI 6, SI 7, SI 12, SI 18, SI 21, SI 22.
SI 3 Sole sourcing and information & knowledge exchange.	SI 8, SI 13, SI 16, SI 20.
SI 4 The role of trust in information and knowledge exchange.	
SI 5 The strength of social ties.	SI 1, SI 2, SI 6, SI 7, SI 12, SI 18, SI 21, SI 22.
SI 6 The exchange of information and knowledge as business courtship.	SI 1, SI 2, SI 5, SI 7, SI 12, SI 18, SI 21, SI 22.
SI 7 The supplier's Sales Engineer as a social mediator between his/her firm and the customer's (Design) Engineers.	SI 1, SI 2, SI 5, SI 6, SI 12, SI 18, SI 21, SI 22.
SI 8 Single Sourcing and information & knowledge exchange.	SI 3, SI 13, SI 16, SI 20
SI 9 The negotiating value of information and knowledge.	
SI 10 Preferred suppliers as a source of information and knowledge.	
SI 11 Physical objects are information bearers in the conceptual design stage.	SI 19
SI 12 The strength of social ties' role in the valuation of information & knowledge exchange.	SI 1, SI 2, SI 5, SI 6, SI 7, SI 18, SI 21, SI 22.
SI 13 The role of Single Sourcing and Preferred Suppliers in the context of information and knowledge exchange.	SI 3, SI 8, SI 16, SI 20.
SI 14 Audits and Supplier Development as mechanisms for the exchange of information & knowledge.	
SI 15 Engineering educational background of Purchasing staff.	
SI 16 The relational assets of Single Sourcing.	SI 3, SI 8, SI 13, SI 20
SI 17 Organizational forms of information and knowledge exchange.	
SI 18 Prioritising relationships in the information and knowledge exchange.	SI 1, SI 2, SI 5, SI 6, SI 7, SI 12, SI 21, SI 22.
SI 19 Physical products, such as prototypes, are information bearers during the design process.	SI 11
SI 20 Single Sourcing and information & knowledge exchange.	SI 3, SI 8, SI 13, SI 16.
SI 21 Relational properties of the information and knowledge exchange.	SI 1, SI 2, SI 5, SI 6, SI 7, SI 12, SI 18, SI 22.
SI 22 The role of social ties in troubleshooting events between customer and supplier firms.	SI 1, SI 2, SI 5, SI 6, SI 7, SI 12, SI 18, SI 21.

Table 8.3 Multicase Themes

Multicase Themes	Subsumed Salient Issues
SOCIAL TIES	SI 1 + SI 2 + SI 5 + SI 6 + SI 7 + SI 12 + SI 18 + SI 21 + SI 22
SINGLE SOURCING	SI 3 + SI 8 + SI 13 + SI 16 + SI 20
PHYSICAL OBJECTS	SI 11 + SI 19

Review of the Single Salient Issues

The occasional empty cells in Table 8.2 mark the Salient Issues that occurred in one firm only. These will be referred to as Single Salient Issues. Before proceeding with the analysis of the three Multicase Themes (in Section 8.3), it is necessary to ascertain that there aren't still more Multicase Themes hidden in the data. Therefore, the six Single Salient Issues (i.e., the Salient Issues SI 4 + SI 9 + SI 10 + SI 14 + SI 15 + SI 17) will be reviewed again in order to establish their possible relevancy to the other firms. The relevancy ratings are shown in Table 8.4.

Table 8.4 Review of the Single Salient Issues, with relevancy ratings High, Medium, and Low. **Note:** The letter 'O' stands for the Origin (i.e., the firm in which the Salient Issue was first identified). The letters 'N.A.' stand for 'not applicable' and mean that the Salient Issue does not apply to the context of the firm's case report.

Salient Issues (SI)	Relevancy ratings for firms A, B, C, and D			
	A	B	C	D
SI 4 The role of trust in information and knowledge exchange.	O	H	H	H
SI 9 The negotiating value of information and knowledge.	O	M	M	H
SI 10 Preferred suppliers as a source of information and knowledge.	O	M	M	M
SI 14 Audits and Supplier Development as mechanisms for the exchange of information and knowledge.	L	O	L	L
SI 15 Engineering educational background of Purchasing staff.	H	O	N.A.	L
SI 17 Organizational forms of information and knowledge exchange.	M	M	O	M

Table 8.4 rates the relevancy of the six Single Salient Issues across the four firms, using the following ratings criteria:

- The rating 'H' (high) means that that the Salient Issue, with its Reflective Comment, is also relevant to the contexts of the other cases, and therefore, the Salient Issue can be upgraded to a Multicase Theme.
- The rating 'M' (medium) means that the Salient Issue, with its Reflective Comment, is not directly relevant to the contexts of the other cases because there are multiple interpretations of the Salient Issue in evidence. Therefore, whenever possible, the researcher thinks of alternative ways to describe the Salient Issue so that it can still be subsumed in one of the extant Multicase Themes.
- The rating 'L' (low), means that the Salient Issue, with its Reflective Comment, is only relevant for the case in which it originates. This may be an indication that the case is atypical, and therefore may deserve special attention in the form of a separate study.

A cursory glance at Table 8.4 shows that none of the Single Salient Issues listed originates in Firm D. This means that all the Salient Issues that were identified in the case report of Firm D had direct applicability to the dyadic information relationships outside Firm D. There are three possible explanations for this exception. A first explanation could be that the cases with fewer informants result in fewer Salient Issues, and therefore, there is less chance for an outlier to occur. With six informants, the case study of Firm D is the smallest one of the four cases. A second explanation could be traced to the clear demarcation of the case. The case was suggested by the Purchasing department of Firm D which stipulated exactly the case parameters (i.e., the case study topic, the number of informants, and the time available for the interviews), thus preventing the researcher to deviate. A third explanation could be sought in the fact that Firm D was the last case study in the series. Therefore, it could be argued that the researcher was able to draw on the experience gained from the earlier cases, and thus was able to identify the patterns in the case evidence with greater accuracy.

Rating Single Salient Issues

The next paragraphs will discuss the ratings given in Table 8.4 to the six Single Salient Issues (SI 4 + SI 9 + SI 10 + SI 14 + SI 15 + SI 17) one by one. Each of the six discussion entries consists of three items:

- a reference to the case report from which the Salient Issue originates;
- a background note on the Salient Issue and the Reflective Comment; and
- justification of the rating given to the Salient Issue.

SI 4: The role of trust in information and knowledge exchange

Reference: The SI 4 originates from the case report of Firm A (Chapter 4).
Background: The Salient Issue and the Reflective Comment (Box 4.7) pertain to the model of 'trust development in professional relationships' (Lewicki and Bunker, 1996). The model consists of three transitional stages, namely:

- the calculus-based trust;
- the knowledge-based trust; and
- the identification-based trust.

The next paragraphs will discuss and rate the relevance of the model of 'trust development in professional relationships', found in the SI 4, to Firms B, C, and D.

Firm B (rating H)

The calculus-based trust underlies the decision by the Purchasing department of Firm B to single source the product parts that Firm B deploys in its products. The decision is a trade-off between risks and benefits. The risk arises from the fact that Firm B does not have a second supplier for most of its product parts. The benefits accrue from the reduced prices that Firm B is able to negotiate by placing a large volume order with one supplier. Another benefit is the cooperative attitude of the supplier in the event of production problems. This is illustrated by the incident of production stoppages and tooling breakdowns at one of the suppliers. The supplier pointed out that a small change in the product's technical drawing could solve the problem. Firm B had two choices. One was to conclude that the supplier was not capable to do the job, and find another supplier to replace him. The second choice was to listen to the supplier's suggestions and try to solve the problem together with the supplier. Firm B chose the second option, because it knew that given the complexity of its products, another supplier was likely to run into the same kind of difficulties. *So we have learned to listen to supplier suggestions, and modify our drawings when needed. That works out best for everyone* (The Purchasing Manager, Chapter 5, Section 5.2.3).

Firm C (rating H)

The knowledge-based-trust is manifest in the relationships that the National Subsidiary and the Regional Subsidiary of Firm C have with their customers. In the National Subsidiary, the Division Customer Solutions often gets a 'blank cheque' from the customers who say: *You know your products better than we do. This is our problem, come with a proposal.* (Chapter 6, Section 6.2.1). In the Regional Office, the Sales Engineer has at times acted as a consultant: the Head of Product Development of a customer firm sought the Sales Engineer's advice about a new project, long before the project was even discussed in the customer firm (Chapter 6, Section 6.2.2).

Firm D (rating H)

The identification-based trust is evident in the incident involving a defect product of Firm D. When the product is returned by the customer as defective, the supplier firm *'assumes its responsibility'* towards Firm D. Even though the supplier firm does not feel responsible for the product failure (the customer did not follow the installation instructions), the supplier firm nevertheless assumes its responsibility because of its longstanding relationship with Firm D. In other words, the two firms identify with each other's position: they join forces in replacing the defect products (Chapter 7, Section 7.2.3).

Justification of ratings: The rating 'H' is justified because the cases B, C, and D all contain elements of the 'trust development model in professional relationships' (Lewicki and Bunker, 1996) in their exchanges of information and knowledge. Therefore, the SI 4 (The role of trust in information and knowledge exchange) will be upgraded to a new Multicase Theme, under the working name 'Trust'(to be discussed further in Section 8.3.4).

SI 9: The negotiating value of information and knowledge

Reference: The SI 9 originates from the case report of Firm A (Chapter 4)

Background: The Salient Issue and the Reflective Comment (Box 4.12) relate to the Affordability initiatives of Firm A in which Firm A mediates the exchange of information and knowledge between the Firm A's suppliers and customers. The ability of Firm A to act as a mediator is given by its knowledge of the supplier market, by the knowledge of low costs engineering solutions, and by the firm's network contacts in the industry. The accumulated knowledge of Firm A gives the firm a negotiating edge when launching Affordability initiatives. The Affordability initiatives result in improved products, the costs of which are borne by the customer and supplier firms. The benefits of affordability initiatives for Firm A are non-monetary, and accrue from the increased reputation and recognition of Firm A as a knowledge partner. The next paragraphs will discuss and rate the relevance of the SI 9 to Firms B, C, and D.

Firm B (rating M)

The AHP (Analytic Hierarchy Process) surveys through which Firm B learns about customers' needs is an example of the negotiating value of knowledge. Although the surveys take between 90-120 minutes to complete, the customers are nevertheless willing to set time aside for this exchange of information and knowledge. Besides having a value as an information source, the AHP surveys have a strategic value: the AHP surveys strengthen the negotiating position of Firm B by demonstrating to the customers the thoroughness (robustness) with which Firm B approaches product development (Chapter 5, Section 5.1 and Section 5.1.1).

Firm C (rating M)
The interpreter's role that Firm C adopts in the research network of biologists and engineers demonstrates the negotiating value of knowledge. Firm C, through its bionic design projects, initiates cross fertilization of scientific and technical disciplines (i.e., initiates the exchange of information and knowledge between two disciplines that would normally not engage in joint research projects). Depending on the commercial feasibility of the design concept, the exchange of information and knowledge can result in a joint product development projects, such as the Gripper component (Chapter 6, Section 6.3).

Firm D (rating H)
The work of Commodity Teams in Firm D is a prime example of the negotiating value of knowledge. The Commodity Teams have no budget of their own but are responsible for the *'lifecycle management of purchased products'* the costs of which are covered by the budgets of the diverse Programmes of Firm D. The Commodity Teams negotiate the terms of cooperation with the (Design) Engineers through sharing knowledge with them about supplier markets and the individual supplier firms. The Commodity Teams hold a key negotiating position because they are the single point of contact for the supplier firms (Chapter 7, Section 7.2.2).

Justification of ratings: The ratings (M, M, and H) given to Firms B, C and D reflect the value of knowledge that can tip the negotiating balance in favour of the knowledge holder. The case evidence shows that such an exchange of information and knowledge goes hand in hand with the quality of social contacts among the parties to the exchange. Therefore, the SI 9 will be rephrased, so as to emphasize the social element in the information exchange (e.g., The negotiating value of knowledge is rooted in the extant social relationships). Consequently, the SI 9 will be subsumed in the Multicase Theme of 'Social Ties' (to be discussed further in Section 8.3.1).

SI 10: Preferred suppliers as a source of information & knowledge

Reference: The SI 10 originates from the case report of Firm A (Chapter 4)
Background: The Salient Issue and the Reflective Comment (Box 4.13) relate to Firm A's tendency to value its 'preferred suppliers' in terms of their prices and performance, rather than in terms of their potential as a source of information and knowledge. In contrast, the supplier firms of Firm A prefer to see themselves as solution providers (i.e., supplying missing knowledge). The next paragraphs will discuss and rate the relevance of the SI 10 to Firms B, C, and D.

Firm B (rating M)
Firm B does not recognize the term 'preferred supplier' (Chapter 5, Section 5.2.1). Instead, Firm B uses the term 'preferred technologies' (i.e., technologies of the product parts that Firm B incorporates in its products). However, most of the 'preferred technologies' are provided by single suppliers.

Firm C (rating M)
Firm C strives to be a preferred supplier to its customers. However, the National Subsidiary and the Regional Subsidiary of Firm C vary in their approach to reach this objective. The National Subsidiary prioritizes its core customers according to their sales turnover, and the industry segment to which they belong. The Regional Subsidiary disregards industrial segmentation, and instead evaluates its core customers according to their need for supplier expertise. Thus, the SI 10 is directly relevant to the situation of the Regional Subsidiary, but is of lesser relevance to the National Subsidiary.

Firm D (rating M)
The supplier firm in the case of Firm D is a preferred and sole supplier. The term 'preferred' has different meanings to the two firms. The supplier firm regards the term 'preferred' as 'being asked first' by the customer to help solve a problem. Firm D, on the other hand, is cautious about the presumed capabilities of suppliers: *You have to be careful that you don't ask suppliers to do something that you would like them to do, but that they themselves are incapable of delivering.* (Purchasing Product Manager, Chapter 7, Section 7.1). On the whole, Firm D believes that most of the needed expertise can be found within Firm D.

Justification of ratings: Firms B, C and D received the 'M' rating because of their ambivalence with regard to the term 'preferred supplier'. However, since the practice of working with preferred suppliers can be regarded as Single Sourcing, the SI 10 will be subsumed in the Multicase Theme of Single Sourcing (to be discussed further in Section 8.3.2).

SI 14: Audits and Supplier Development as mechanisms for the exchange of information and knowledge.

Reference: The SI 14 originates from the case report of Firm B (Chapter 5)
Background: The Salient Issue and the Reflective Comment (Box 5.5) signal the wish of the (Design) Engineers of Firm B to be involved in the supplier's Audits and Supplier Development. The next paragraphs will discuss and rate the relevance of the SI 14 to Firms A, C, and D.

Firm A (rating L)
The Audits in Firm A are the task of the Purchasing Department. The Audits focus on costs, efficiency and logistical processes of supplier firms. The Purchasing department has a number of systems at its disposal with which to evaluate suppliers' performance. The outcome of Audits can be a starting point for discussions with suppliers about how to improve their performance. Although the (Design) Engineers and the Purchasers cooperate closely in selecting product parts, and in the choice of suppliers through their joint participation in the Affordability initiatives and in the Material Review Boards (there is one for each Programme), the involvement of the

(Design) Engineers in Audits and in Supplier Development is minimal. In Firm A, Supplier Development is understood as a mechanism to bring suppliers' performance to a higher level, rather than as a mechanism to establish the exchange of information and knowledge in NPD.

Firm C (rating L)
The National Subsidiary carries out regular Audits of its Dealers network through which it serves smaller customer firms. The Regional Subsidiary does not have a Dealers network.

Firm D (rating L)
The Commodity Teams carry out occasional Audits of prospective new suppliers. The Audits focus on costs, performance, and logistics issues.

Justification of ratings: The 'L' ratings for the found evidence in Firms A, C and D indicate that the potential of Supplier Development as a link up to the information and knowledge of suppliers, although advocated in the literature (Lamming, 1993, 1996, 2005; Modi and Mabert, 2007; Wagner and Krause, 2009), has as yet to be implemented by Firms A, C, and D.
The SI 14 originates in Firm B where Supplier Development can be described both as an act of pioneering and a legacy. It is 'pioneering', in the sense that Firm B is the only firm among the participating firms with a Supplier Development Engineer on its staff. It is a legacy, in the sense that the function of Supplier Development Engineer had been introduced when Firm B was a subsidiary of an US firm.
The reasons why Supplier Development has received so little attention in practice, despite it being recommended in the literature, deserve further study, and will therefore be proposed as a topic for future research in Chapter 9.

SI 15: Engineering educational background of Purchasing staff

Reference: The SI 15 originates from the case report of Firm B (Chapter 5)
Background: The Salient Issue and the Reflective Comment (Box 5.6) reveal that communication between (Design) Engineers and Purchasers is easier when the Purchasing staff have technical educational background. The next paragraphs will discuss and rate the relevance of the SI 15 to Firms A, C, and D.

Firm A (rating H)
The fact that the Purchasing department participates, and often takes the lead, in diverse activities of Firm A (e.g., Affordability initiatives, Trade studies, Material Review Boards, etc.) is a testimony to the esteem and appreciation in which the Purchasing department is held in Firm A. The Purchasing Manager has both technical and business education background, and has been with Firm A for some thirty years.

Firm C (rating N.A.)
In Firm C, Purchasing is a back office function.

Firm D (rating L)

The trend towards employing Purchasers without technical education is viewed with concern by the senior Purchasing staff in Firm D. It is argued that most of the misunderstandings between (Design) Engineers and Purchasing can be attributed to the lack of technical background on the part of Purchasers.

Justification of ratings: The ratings (H, N.A., and L) given to Firms A, C and D reflect the mixed evidence about the status of the Purchasing profession: ranging from a high appreciation to a lack of awareness of what the work of Purchasers entails.

The discrepancy between the firms' attitude towards Purchasing, together with the concern about the shortcomings in technical educational background of the new generation of Purchasers, suggest that the Purchasing profession is going through profound changes. Surprisingly, the present thesis found no evidence of the Purchasing's participation in NPD, despite the fact that such participation has been advocated in the literature for more than twenty years (Burt and Soukup, 1983; Di Benedetto et al., 2003; Lakemond et al., 2001; Wynstra et al., 1999, 2000, 2001. 2003). Van Weele (2010: 49), commenting on the low involvement of Purchasing in the early stage of NPD (when product specifications are determined, and materials selected), observes: "The theory runs ahead of practice here."

Given the evolving nature of the Purchasing profession, it may be expected that the research on the Purchasers' role in the supply chain management will continue to hold a permanent place on the research agenda for years to come (Carter and Narasimhan, 1996; Ramsay and Croom, 2008; Rozemeijer, 2008; Van Weele and Rozemeijer, 1996). The topic will be returned to in Chapter 9.

SI 17: Organizational forms of information and knowledge exchange

Reference: The SI 17 originates from the case report of Firm C (Chapter 6)

Background: The Salient Issue and the Reflective Comment (Box 6.2) refer to the two different approaches with regard to organizing the internal exchange of information and knowledge found in Firm C. On the one hand, the MBO (management by objectives) approach, as applied by the National Subsidiary, where the dissemination of information and knowledge is subordinate to the firm's sales turnover. By comparison, the Regional Subsidiary considers the internal dissemination of information and knowledge as the cornerstone of the firm's relationship with its customers. The next paragraphs will discuss and rate the relevance of the SI 17 to Firms A, B, and D.

Firm A (rating M)

Firm A has diverse organizational bodies in which the exchange of information and knowledge takes place. However, it needs to be said that these organizational bodies had not been set up for that particular purpose. For example, the Material Review Boards in which both Purchasers and (Design) Engineers participate have the task to

select suppliers and product parts for diverse Programmes, and to prepare Risk Mitigation Plans. Clearly, this work cannot be done without exchanging information and knowledge about the Firm A's experience from previous Programmes.
Similarly, the Affordability Committee has as its task to reduce the total Programme costs. Again, exchanging information and knowledge about the supply market is part of the Affordability Committee's work. The exchange of information and knowledge can be described as informal, but taking place in formal settings. Thus, the exchange is driven by social relationships that participants in these organizational bodies have with one another, and with the world outside Firm A.

Firm B (rating M)

The organizational body in which information about suppliers and their products is being exchanged is the Sourcing Committee, with broad participation from Purchasers, R&D Engineers, Product Development (PD) Engineers, Quality Control Engineer, and Manager Engineering Projects. The prime purpose of the Sourcing Committee is to take decisions with regard to supplier selection. In addition to the Sourcing Committee, Firm B has a semi-formalized exchange of information and knowledge between R&D Engineers and PD Engineers in the concept stage of product development. The R&D Engineer notes: *Starting from a second product sketch, PD Engineers are already looking over our shoulder. They need to feel confident that the product can be mass produced.* (Chapter 5, Section 5.1.1) The PD Engineer concurs: *It certainly isn't the case that R&D would 'throw the design concept over the wall' to us. They involve us in the concept design. The conceptual thinking has become part of our work as well. They don't have the capacity to do it alone.* (Chapter 5, Section 5.2.1). Thus, the exchange of information and knowledge between R&D Engineers and PD Engineers in Firm B may have been born out of necessity, but it is now part of the design process.

Firm D (rating M)

In Firm D, the forum for the exchange of information and knowledge are the Project Teams that work on the development of a product until it reaches *the first of a series'* stage, after which the product goes into production, and the Project Team is disbanded. The temporary character of the Project Team leads to fragmentation in knowledge sharing. As a result, knowledge sharing is largely driven by social relationships among the (ex) Project Team members.

Justification of ratings: The SI 17 is too generic to be applicable across the organizational forms found in Firms A, B and D, and the ratings (M, M, and M) reflect this. The case evidence suggests that the quickest and most reliable way of exchanging information and knowledge appears to be a face-to-face interaction. Therefore, the SI 17 will be rephrased to highlight the value of the face-to-face interaction in optimizing the dissemination of information and knowledge within the firm (e.g., The contribution of social relationships to the organization of internal information and knowledge). In consequence, the SI 17 will be subsumed in the Multicase Theme of 'Social Ties' (to be discussed further in Section 8.3.1).

Identification of the Multicase Themes

The review of the six Single Salient Issues with their ratings, shown in Table 8.4 , resulted in the augmentation of the Multicase Themes from three to four.

The Multicase Theme that has been added is SI 4 (The role of trust in information and knowledge exchange); its working name is 'Trust'.

Three of the Single Salient Issues (SI 9, SI 10 and SI 17) have been subsumed into the extant Multicase Themes. Specifically, the SI 9 (The negotiating value of information and knowledge) and the SI 17 (Organizational forms of information & knowledge exchange) have been subsumed into the Multicase Theme 'Social Ties'.

The SI 10 (Preferred suppliers as a source of information and knowledge) has been subsumed into the Multicase Theme of 'Single Sourcing'.

The SI 14 (Audits and Supplier Development as mechanisms for the exchange of information and knowledge) and the SI 15 (Engineering educational background of Purchasing staff) were found to have only limited applicability across the contexts of the four focal firms. However, both SI 14 and SI 15 will be discussed as potential areas for future research in Chapter 9.

The next section will analyse the Multicase Themes.

8.3 ***Stage Two:*** **The analysis of the Multicase Themes**

The four Multicase Themes mirror both the process-related and the product-related situations connected with the utilization of supplier information and knowledge in the four focal firms during the FFE of NPD. The Multicase Themes of 'Social Ties' and 'Trust' can be said to represent the process-related situations, whereas the Multicase Themes of 'Single Sourcing' and 'Physical (Boundary) Objects represent the product-related situations.

As shown in Figure 8.1, the present thesis deploys the Multicase Themes in two ways. First, the Multicase Themes are used to validate the Research Questions in Section 8.4. Second, the Multicase Themes are examined in relation to the Conceptual Framework to establish the fit between the Conceptual Framework (Figure 3.3, Chapter 3) and the evidence captured in the Multicase Themes. This results in the formulation of the Cross-case Assertions about the Multicase Themes in Section 8.5.

The total number of the Multicase Themes that emerged from the Salient Issue analysis (Section 8.2) is four, and they will be addressed in the following sections:

- Social ties (Section 8.3.1);
- Single Sourcing (Section 8.3.2);
- Physical objects (Section 8.3.3); and
- Trust (Section 8.3.4).

The diverse manifestations of the Multicase Themes in the four cases will be analysed against the background of primary scholarly work relevant to the Multicase Theme under study (analogous to a peer review) in order to establish the Multicase Themes' credibility. Each section concludes with the researcher's Reflective Comments.

8.3.1 Social ties

The analysis of the function of social ties in the exchange of information and knowledge, as found in the participating firms, follows the research of Stanko et al. (2007) who translated the dimensions of tie strength into the context of business relations. The original definition of tie strength by Granovetter (1973: 1361) applies to interpersonal relations:

> *The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie.*

The note 'probably linear' is generally interpreted as suggesting a continuum of tie strength ranging from weak to strong. Starting with the weak ties, the amount of time (i.e., the duration of the relationship) in weak ties is transitory. The 'emotional intensity' and 'intimacy' (as in 'mutual confiding') in weak ties are incidental. The weak tie relationship is non-reciprocal and non-committal. At the other end of the continuum of tie strength are strong ties where all four dimensions of tie strength can be found in full.

The translation of the tie strength definition (Stanko et al., 2007) into the customer/supplier context reads as follows:

- 'Time' refers to the length of the relationship. Over time, with repeated contacts, the relationships between customer and supplier firms grow in strength and in trust.
- 'Emotional intensity' refers to the degree to which business partners have feelings for each other beyond the economic transaction. ("We would feel bad if our firm switched away from this supplier for this type of product"). It represents the strength of emotional bonds ("This manufacturer means more to us than the product they provide us. Their products create excitement within our organization.").
- 'Intimacy' or 'mutual confiding' refers to sharing of fine grained, sensitive, and confidential information through both formal and informal channels of communication ("We regularly provide this supplier with long-range forecasts of product requirements.").
- 'Reciprocal services' refer to the extent that the parties take active responsibility for the partner's well-being, as well as their own. There exists a unity of interest and solidarity. Problems are solved jointly.

The next paragraphs and Table 8.5 illustrate and discuss the four dimensions of the strength of social ties in the context of the firms A, B, C, and D.

Table 8.5: Manifestations of tie strength dimensions in the information relationships that Firms A, B, C, and Firm D have with their suppliers and customers.

Tie strength Dimensions	Firm A	Firm B	Firm C	Firm D
Time (length of relationship).	Long-term relationships with preferred suppliers. Inverse appreciation of supplier knowledge by PD Engineers and Project Managers.	Frequent personal meetings between PD Engineers and the Manufacturing Engineers of the supplier firm. Inverse appreciation of supplier knowledge by PD Engineers and Project Managers.	Former job of the Product Manager helped in setting up a pilot project at the customer firm of the National Subsidiary. In contrast, the setting up of a pilot project at the Regional subsidiary resulted from a long-standing relationship with a customer firm.	The supplier firm has been a preferred supplier for 30 years.
Emotional intensity (beyond economic transaction)	Cooperation within the Integrated Product Team (IPT).	Supplier Director's approach of going *'back to the basics'* during the first meeting with the customer firm. Bonds with suppliers through knowledge about and of the firm result in Single Sourcing.	Precautions taken to prevent leakage of customer firm's knowledge during the pilot project. Sales Engineer acts as a consultant to customer firms.	Not overestimating the supplier's real capabilities. Taking into account the supplier's production schedule.
Intimacy/ Mutual confiding (sharing confidential information)	Hand tool development. Material technology Research	PD Engineers negotiate dimensions and tolerances in drawings with the Manufacturing Engineers of the supplier firm. PD Engineers learn about supplier's tooling.	Exchange of test results from pilot projects, videos, prototypes.	Upgrade of the Firm D's product. Joint tests and confidential product information exchange. The (Design) Engineer's view: *Organizations are based on relationships rather than on formal structures.*
Reciprocal services (unity of interest, solidarity)	Identifying supplier new technology and introducing it to the customer.	Supplier firm's support goes beyond the duration of the project.	Customer firms agree to the request of the Subsidiaries to take part in the present thesis.	The supplier firm *'assumes its responsibility' to* Firm D by replacing a defective product part.

Social ties in Firm A

Time: All suppliers have a longstanding relationship with Firm A. They are the so-called preferred suppliers, that is, supplier firms that have been screened and approved by the Purchasing department of Firm A. The (Design) Engineers spend more time with the supplier's Sales Engineers and are therefore more appreciative of the Sales Engineers' contribution to NPD than Project Managers.

Emotional intensity: The work of the Integrated Product Team (IPT) is an example of cooperation that goes beyond the line of economic transaction. The IPT cooperation was born out of failure of a previous project. Despite this experience, both the (Design) Engineer of Firm A and the supplier's Sales Engineer felt they could learn from past mistakes. The supplier's Sales Engineer understands and empathises with the pressure that the (Design) Engineers of Firm A work under: *They are under so much pressure to get a qualified part just in time before the production begins, so that they need to work with one preferred supplier only. And luckily, that's us. […]. We now also solve their issues to meet their schedule. Firm A had a problem and found in us a partner who can help solve the problem. And they trust us.* (Chapter 4, Section 4.2)

Intimacy/Mutual confiding: The Hand Tool Development (Chapter 4, Section 4.2.1) illustrates the exchange of confidential information between Firm A and a supplier firm. Firm A sought advice from the supplier firm about a problem that Firm A encountered in the pre-series phase of their products. The problem concerned the cumbersome process of product maintenance and modification. The Chief Engineer of Firm A motivates the request as follows: *They [the supplier firm] have a more positive attitude to this kind of questions. You can discuss a problem with them without having to take out your wallet first […].* The supplier firm's team, led by the supplier's Sales Engineer, developed a new hand tool for Firm A. The supplier's Sales Engineer stresses that: *We can only work with companies that have sufficient engineering background.*

This statement implies that sharing a problem with a supplier firm, and cooperating in finding a solution to the problem, requires a common knowledge base. However, having a common knowledge base is sometimes not enough, as shown in the approach of Firm A to Material Technology research (Chapter 4, Section 4.1.2.). Even though the research interests of R&D divisions of supplier firms and the research interests of Firm A for new material technology coincide (i.e., the common knowledge base is there), the two parties doubt each other's research integrity. More particularly, Firm A is doubtful about the research impartiality (integrity) of supplier firms. The conclusion that can be drawn form this is that for intimacy/mutual confiding to take place, trust is a necessary precondition.

Reciprocal service: The reciprocal support that Firm A and a supplier firm give each other is demonstrated in the way the two companies join forces in introducing a new technology of the supplier firm to a customer of Firm A (Chapter 4, Section 4.2.1).

The supplier's Sales Engineer explains the back-up function of his firm to Firm A: *As soon as you make a step in technology, you need to make people confident about the safety issues. You need a strong argumentation for this and you need support which we can provide. If there are technical issues, we have a technical team that will react and make corrections. On the other hand, we need the support of Firm A to convince the customer firm of the benefits of our new technology.* The mutual support that Firm A and the supplier firm give to each other is an example of reciprocal sharing of responsibility.

Social ties in Firm B

Time: The supplier firm of steel casing/housing is a preferred supplier of Firm B, but of recent date. The time length in this case is compensated by the high frequency of contact between the Product Development (PD) Engineers of Firm B and the Manufacturing Engineers of the supplier firm. Given the geographic proximity of the two firms, personal meetings are easy to organize. The time dimension comes to light in the inverse appreciation of supplier knowledge. The PD Engineers, who have frequent contact with the supplier's Manufacturing Engineers, appreciate the information and knowledge received from the supplier firm more than the Project Manager whose contacts with suppliers are at the management level, and concern project budgets.

Emotional intensity: The supplier's Director makes time to explore the background of the project, which he calls '*going to the basics.*' In his first meeting with the customer firm, the Director tries to learn and understand the firm's point of view: *Mostly we are not involved in the early stages of product development; most of the time the development has moved on. That means that choices have been made, and the development has already taken a certain direction. So we try to go back a little bit and ask: "What is your intention? What did you mean by that choice?" And most of the time we discover (that's why we do it) that the choices were made because the customers lacked knowledge. They didn't know any other way, and we tell them that there are other possibilities, that things can be done differently. But, you have to bear in mind that sometimes the customer does not like to go back over his decisions (or there is no time), so you have to be careful to suggest that* (Chapter 5, Section 5.2.1).

The PD Engineers of Firm B appreciate the supplier's engagement with the project: *[…] what makes this particular supplier attractive: they enjoy the challenge; they like to have an opportunity to tackle new problems. And if something cannot be done, they come with good arguments. They consult and deliberate with us.* Among the reasons for selecting this particular supplier was 'the energetic personality' of the supplier's Director Sales & Engineering (Chapter 5, Section 5.2.1).

The Quality Control Engineer characterizes the relationship that Firm B has with its preferred suppliers: *With an old supplier firm you have a certain bond; you have knowledge about and of the firm* (Chapter 5, Section 5.2.1). It is this feeling of a bond that in Firm B frequently leads to the choice of Single Sourcing.

Intimacy/Mutual confiding: The exchange of confidential information has two aspects. On the one hand, the exchange concerns the negotiating of dimensions and tolerances in technical drawings, as submitted by PD Engineers to the supplier firm. On the other hand, the exchange involves learning by PD Engineers about the quality and efficacy of the supplier's tooling.

The PD Engineer comments*: Of course, the tooling is the supplier's own design, and we don't have any influence over it. The supplier can only tell us what the tooling can or cannot do. And then you often get a dimensioning discussion* (Chapter 5, Section 5.2.1).

Reciprocal service: Supplier's willingness to help the customer firm can extend beyond the duration of the project. The PD Engineer recalls one example of reciprocity: *For our current project on a low-cost product we needed a prototype of a single spring component. Eventually, we found a supplier firm (Suppliers are usually not interested in making prototypes for you if there is no prospect of a whole project.), but the delivery time was four weeks. And then our R&D Engineer suggested that perhaps the supplier firm of steel casing/housing might be able to help. Their website did not say that they also made that kind of products. However, when we telephoned, the Director asked to have our 3D files sent, and said, that because we were such good customers, he would have the component ready for us in two weeks* (Chapter 5, Section 5.2.1)

<u>Social ties in Firm C</u>

Time: The customer firm of the National Subsidiary that was selected for the pilot project with the Gripper component does not belong to the Subsidiary's top twenty core customer firms that the National Subsidiary usually prioritizes for product development. The firm was nevertheless invited to take part in the pilot because of the expected applicability of the Gripper component in the agriculture sector to which the customer firm belonged. Interestingly, the Product Manager in charge of the pilot in the National Subsidiary knew the Director of the customer firm from his previous job in the agri-industry. In that sense, the length of relationships at the personal level helped establish contacts at the project level. In contrast, the pilot at the customer firm of the Regional Subsidiary was a result of a longstanding relationship between the Director of the customer firm and the Sales Engineer of the Regional Subsidiary: *We don't want to change a winning team* (Chapter 6, section 6.2.2)*,*

Emotional intensity: During the pilot project, the National Subsidiary of Firm C took precautions to prevent the leakage of knowledge from customer firms participating in the pilot. For example, the Sales Engineers of the Subsidiary were excluded from the pilot projects for fears that they might accidently divulge product information while visiting other customer firms.

In the Regional Subsidiary, an example of emotional intensity would be the fact that the Sales Engineers sometimes act as a consultant for customer firms. Once, the Sales Engineer recommended to the Head of Development of a customer firm an engineering bureau for a NPD project.

His emotional bond with the customer firm transpires from the following comment: *I don't know if he [the Head of Development] had asked anyone [in his firm]. Besides, I knew that his firm had cooperated with that particular engineering bureau before. But the Head of Product Development was new to the firm and was not aware of it. I had no qualms about passing on the information because I knew that the engineering bureau was very good. I don't use my name to recommend a firm unless I am sure that they are really good.* (Chapter 6, Section 6.2.2)

Intimacy/Mutual confiding: The pilot project on the Gripper component involved the exchange of test results in the form of prototypes and product videos between the (Design) Engineer/Director of a customer firm and the Product Manager of the HQ of Firm C where the Gripper component was developed.

Reciprocal service: It could be argued that the very fact that the National and Regional Subsidiaries of Firm C introduced the researcher of the present thesis to their customers, and that these customer firms agreed to the interviews, might be taken as evidence of reciprocal service between the Subsidiaries of Firm C and their customers, a service from which the researcher was allowed to benefit.

<u>Social ties in Firm D</u>

Time: The supplier firm has been a preferred supplier of Firm D for 30 years. The contacts between Firm D and the supplier firm took place at the level of the Commodity Team members of Firm D and the supplier's Account Manager.

Emotional intensity: Not overestimating the supplier's real capabilities is inherent to the Firm D's customer/supplier relationship: *You have to be careful that you don't ask suppliers to do something that you would like them to do, but that they themselves are incapable of delivering. Suppliers may agree to the proposition because they want to get an order from Firm D, or because they want to acquire and develop new capabilities, but when the proposition pushes them to perform above their potential, that can lead to a fiasco with suppliers* (Purchasing Product Manager, Chapter 7, Section 7.1)

Intimacy/Mutual confiding: The supplier firm suggests upgrading a product of Firm D. Both firms engage in joint tests and exchange confidential product information. The role that interpersonal relationships play in the exchange of information is generally rated high. The (Design) Engineer puts it as follows*: Personally, I think that the functioning of an organization is based on relationships rather than on a formal structure. You seek advice from someone who you know. You don't stop to think that there could be official channels for contacting people* (Chapter 7, Section 7.2.2).

Reciprocal service: When the upgraded product of Firm D is returned by a customer as defective (the defect occurred because of an incorrect installation procedure at the customer site), the supplier firm *'assumes its responsibility towards Firm D'* and helps Firm D to replace the defective product part.

BOX 8.1

REFLECTIVE COMMENT on the Multicase Theme of SOCIAL TIES based on the Tie Strength Dimensions (the 'rows' of Table 8.5).

Time:

The length of relationship, either at the level of the firm, or at the level of individuals, clearly affects the state of the relationship between two business partners. - A rather curious but revealing manifestation of time was found in the inverse appreciation of supplier knowledge held by the (Design) Engineers (called PD Engineers in Firm C) and by the Project Managers. The (Design) Engineers who have frequent hands-on exchange of knowledge with the suppliers' Sales Engineers appreciated the received knowledge more that the Project Managers, who because of their position in the firm's hierarchy, had no direct contact with suppliers' Sales Engineers, and consequently, had a tendency to downplay the potential contribution of suppliers' Sales Engineers to NPD knowledge. Thus, at the individual level, the length of relationship may entail a hierarchical dimension.

Emotional intensity:

The case evidence suggests that the emotional intensity of firms (i.e., the interest that business partners show to one another) can be 'open' or 'pre-emptive'. Open, as in initiating integrated product teams in which the two partners share the ups and downs of the NPD process, or inquiring about partner's NPD motives. Pre-emptive, as in anticipating the shortcomings of business partners, or as in taking precautionary measures to prevent leakage of knowledge.

Intimacy/Mutual confiding:

The degree to which business partners share confidential knowledge is largely determined by the urgency of the situation and the interdependency of business partners. The case evidence from the four cases shows an overlap between the tie dimension of 'Emotional Intensity' and the tie dimension of 'Intimacy/Mutual Confiding'. The overlapping element concerns the issue of trust which the two dimensions of tie strength imply but do not specify. Strong ties, with their norm of reciprocity and long-term relationships, take trust for granted. But do all collaborative relationships require the presence of strong ties? Do weak ties operate on 'blind trust'? The research by Levin and Cross (2004) propose a concept of 'trusted weak ties' (Also included in the Conceptual Framework for this study in Chapter 3, Figure 3.3). The concept of trusted weak tie is grounded in the assumed competence and benevolence underlying a tie relationship. Since the issue of trust has been identified as a Multicase Theme, it will be discussed further in Section 8.3.4.

Reciprocal services:

Reciprocity is the touchstone by which the business partners evaluate the worth of their relationship. Giving support to one another when needed, such as 'assuming responsibility' in troubleshooting situations.

8.3.2 Single Sourcing

Single Sourcing represents a sourcing strategy whereby the firm decides, by choice, to purchase its commodities and/or materials from one supplier only. When such purchasing decisions are taken by necessity because there is just one supplier firm from which the commodities and/or materials are available (e.g., the proprietary product parts), then the firm engages in sole sourcing. An alternative to Single Sourcing strategy is multiple sourcing whereby a firm decides to purchase identical products from several suppliers. Dual sourcing is a variant of multiple sourcing and involves a 'second source' of supply (Faes and Matthyssens, 2009; Gelderman and Van Weele, 2003) .

The risks and benefits of Single Sourcing and multiple sourcing have been contested for years in the literature (Swink and Zsidisin, 2006; Trevelen and Schweikhart, 1988). The most often cited sourcing risks are disruption of supply and price escalation. Examples of disruption of supply are a supplier's bankruptcy, a natural disaster, or labour unrest causing cessation of production at the supplier site. Price escalation can result from a lock-in position of the customer firm (i.e., the customer firm is dependent on one supplier) when the supplier firm can dictate its prices. The strategy of multiple sourcing is recommended because it protects the customer firm from such risks, while allowing it to select suppliers with the lowest price bids. In multiple sourcing situations, the customer firm has an arm's length relationship with suppliers.

In contrast, the benefits of Single Sourcing include increased and improved two-way communication between the customer and supplier firm which enables the firms to jointly counter product quality problems as they arise. Single Sourcing leads to lower costs of ordering because the information about production schedules can be exchanged in advance. Single Sourcing also leads to price reductions resulting from ordering large volumes. Trevelen and Schweikhart (1988) point out that most firms deploy a mix of these two sourcing strategies, and are guided in the choice by the type and size of the firm, and the industry in which the firm operates.

Single Sourcing has emerged in the present thesis as a Multicase Theme because the found evidence suggests that Single Sourcing is conducive to the exchange of technical knowledge between the customer and supplier firm, and can lead to joint product development.

The idea of close cooperation with suppliers is not new. Trevelen (1987) notes that when in 1982 W. Edwards Deming first advocated the benefits of Single Sourcing, the advice went unheeded in the United States, where price bargaining was considered more effective than collaborative relationships with suppliers. Japan, on the other hand, was more receptive to Deming's arguments for Single Sourcing. The Japanese Just-in-Time (JIT) sourcing strategy is based on the idea of eliminating waste by cutting down large inventories of product parts.

The JIT sourcing strategy leads to reducing the number of suppliers and to establishing collaborative relationships through lean supply (Lamming, 1993). The observation that Trevelen and Schweikhart (1988) made 25 years ago with respect to the application of sourcing strategies is particularly relevant for the context of the present thesis. Trevelen and Schweikhart (1988) distinguish between sourcing for production and sourcing for development. The strategy of multiple sourcing is better suited for sourcing for production, whereas sourcing for (product) development is better served by the Single Sourcing strategy. The strategy of multiple sourcing provides a broader market overview of potential sources of technological development, whereas a Single Sourcing strategy enables access to supplier technology and mutual learning.

The next paragraphs and Table 8.6 reflect on the advantages and disadvantages of Single Sourcing and multiple sourcing as experienced in Firms A, B, and D. Firm C is not included in the overview because the firm was studied for its relationships with customers, not suppliers. However, the interviews with two customer firms of Firm C revealed that they regarded Firm C as their preferred supplier.

Table 8.6 Sourcing Strategies of Firm A, B, and D

Firm	Single Sourcing		Multiple Sourcing	
	Advantages	Disadvantages	Advantages	Disadvantages
A	Knowledge sharing in joint NPD projects. Flexibility and feedback in design. More time for product quality issues. Competitive lead-time advantage.	Dependency on one supplier (a lock-in situation). Imposed Single Sourcing, e.g., proprietary parts, or product part compatibility. Need for Mitigation Plans	Competitive pricing. Broad overview of supply market. COTS (commercial off- the-shelf) products.	'Dual sourcing' of supplier firms to ensure that their firm gets the customer's order. Arm's length relationship between customer and supplier firms..
B	Face-to-face contacts. Learning about supplier's manufacturing process. Relationship history. Product quality improvements. Constant manufacturing performance. Information & knowledge exchange. Supplier sells knowledge. Proof that the product is manufacturable.	Slow supplier's response to design modifications. Vulnerability of having only one supplier.	Applied only for standard product parts.	Time and energy intensive. Puts extra pressure on product information dissemination. Design modifications at multiple suppliers.
D	Relationship history. Product customization. Exchange of information & knowledge.	Disruption of supply through change in management.	Not applicable. Firm D purchases product parts in small volumes.	COTS products difficult to make compliant with military specifications.

Single Sourcing in Firm A

Firm A pursues a strategy of Single Sourcing avoidance. The Purchasing department admonishes the (Design) Engineers to *set off their technical blinkers,* and think how the choice of a particular product part is going to affect the total costs of a Programme. The benefits of a multiple sourcing strategy are seen in the competitive prices, and in the overview of the supply market that such a strategy provides.

The knowledge of supply market offerings is particularly valuable to Firm A because its customers expect that Firm A recommends optimal product parts alternatives. To meet this expectation, Firm A draws the customers' attention to COTS (commercial off-the-shelf) products whenever possible.

Firm A perceives Single Sourcing as risky because of the dependency on one source, and the ensuing lack of competition. However, Single Sourcing is sometimes unavoidable, as in the case of specific needs of the (Design) Engineers. The current practice is that purchasing decisions are made by the Material Review Boards in which both Purchasers and (Design) Engineers participate. The (Design) Engineer describes the decision making process as follows: *If we have product parts from two suppliers, we leave the choice to Purchasing (i.e., which supplier to choose). But if we, as (Design) Engineers, have specific needs, then we will make the choice (i.e., which product part to use).* (Chapter 4, Section 4.2.2).

The supplier firms of Firm A respond to the Firm A's multiple sourcing strategy with a 'dual sourcing' strategy of their own. The strategy entails that in addition to contacts with Firm A, the supplier's Sales Engineers also approach the customer firms of Firm A, so as to make sure that their firm gets the order. In the words of one Sales Engineer: *It can do no harm when information about our products comes from two directions: from myself to Firm A, and from my colleague to the customer of Firm A* (Chapter 4, Section 4.1.1). It could be argued that the 'dual sourcing' strategy of suppliers undermines the task and authority of Firm A when advising its customers on matters concerning the choice of product parts. The 'dual sourcing' strategy is also a reflection of the arm's length relationship between Firm A and its suppliers.

Other situations when Single Sourcing is inevitable arise when Single Sourcing is imposed on Firm A. For example, when a customer firm requires the use of proprietary parts, or when the compatibility of product parts is at stake. In such cases, Firm A adopts the strategy of Single Sourcing by necessity. The strategy involves drafting a list of product part replacements, as part of the Risk Mitigation Plan prepared by the Material Review Board. Interestingly, Firm A opted for Single Sourcing (i.e. adopted the strategy of Single Sourcing by choice), in its own product development projects when it wanted to bring improvements to Firm A's manufacturing. The Hand Tool development project (Chapter 4, Section 4.2.1) or the development of a Tooling Machine (Chapter 4, Section 4.1.2) required knowledge sharing, flexibility and feedback in design, and extra attention to quality issues.

Single Sourcing by choice was also the driving force behind the joint project between Firm A and its supplier involving a product component (Integrated Product Team), which resulted in a lead-time advantage for Firm A over its competitors.

The Senior (Design) Engineer comments on the project*: What matters to us most is the fact that the supplier is the only manufacturer of the product part. Our competitors can buy the product part but they need to qualify it first before they can use it. And that takes time. […] So if a customer needs to have that particular product part quickly, he must come to us because we have qualified the part. We can meet lead time requirements, whereas our competitors cannot* (Chapter 4, Section 4.2.1). In other words, the benefit of keeping ahead of competitors outweighs the resulting dependency on one supplier (i.e., a lock-in situation).

Single Sourcing in Firm B

Most of the product parts of Firm B are single-sourced. The reasons for Single Sourcing are several. The Head of Product Development points out the dilemmas: *When you are looking for a standard product part, then you can always find a second, or a third supplier. But for highly specialized products such as deep drawn stamped parts, that require expensive tooling, multiple or dual sourcing is not always possible. The tooling (designed by the supplier firm) is owned by Firm B, so that should the current supplier go out of business, we can move the tooling to another supplier. And, of course, you need to go twice through the product release procedure* (Chapter 5, Section 5.2.1). Thus, Firm B practices the strategy of Single Sourcing by choice. This strategy is more or less endorsed by both Purchasing and Engineering of Firm B as the following comments illustrate.

The Purchasing Manager describes Single Sourcing as a trade-off: *Once you divide your order volume in two parts you lose the price reduction benefit. So we try to minimize the risks by making sure that the suppliers we select are sound financially, we audit their manufacturing process. They need to score at least 80 points of 100 on our assessment checklist. […] Suppose we would have a second source for the current supplier of the deep drawn stamped parts. That would mean investing in two sets of tooling and that costs 150.000 a piece. […] When we do our benchmarks, it is rare that we come across a supplier with better prices than those of our current suppliers. So the long-time relationships are paying off* (Chapter 5, Section 5.2.3).

The Quality Control Engineer stresses the importance of certification in the selection of suppliers. All suppliers of Firm B are required to: *sign a quality contract, be certified to ISO/TS 16949 Standard, have minimal customer complaints, and have production system that works at 10 ppm (product parts per million) rejection level, i.e., 10 rejects per million.* The Quality Control Engineer regards Single Sourcing as less stressful: *Multiple or dual sourcing costs much more time and energy. Introducing design modifications means synchronizing the production process at two or more suppliers, and that puts extra pressure on your information dissemination. We invite bids from 3-4 potential suppliers, but we usually end up giving the order to the supplier firm that we had worked with before. This is especially the case when there are little differences in the financial/technical assessment.* On the negative side, the Quality Control Engineer mentions a supplier's slow response to requests for design modifications: *We are a big customer of this Japanese firm, and yet, when we require design modifications, there are few incentives to motivate this supplier firm because they know we are dependent on them […]. But there are positive aspects too. We know their product portfolio, and that knowledge help us with design* *modifications. With another supplier we would have to build up that knowledge from scratch* (Chapter 5, Section 5.2.1)

The Manager Engineering Projects explains how in Firm B the bidding process and Single Sourcing by choice are intertwined: *When we try to establish the manufacturability of a product, we first approach the supplier firms with which we had worked in the past. We tell them that it is a new product, and they can join in the bidding process. But there is no promise on our part that they will actually get the order. However, they have an advantage in that they have a relationship history with us. Their knowledge of our supplier conditions enables them to come with an optimum price quotation* (Chapter 5, Section 5.2.1)

The Head of Product Development stresses the value of personal contact: *We start the project process with the objective of finding 4-5 suppliers, request quotations and discuss the selection in the Sourcing Committee. For (Design) Engineering it is important to know whether the supplier firms have the necessary manufacturing capabilities. Suppliers can send in wonderful quotations, but can they actually make the product? For that to find out you often need to have face-to-face contact with the supplier, so that they know exactly what we need. Doing this with four or five suppliers costs a lot of time. But we have done it often with two suppliers* (Chapter 5, Section 5.2.1).

The Product Development (PD) Engineer underlines that both Firm B and the supplier firm benefit from close collaboration: *You don't know how flexible the supplier's manufacturing process is. To design a product in such a way that it is easier to manufacture, can cut back the costs of the product considerably. Improving the manufacturing process increases both the supplier's productivity and the product quality, and we benefit from the constant manufacturing performance* (Chapter 5, Section 5.2.1).

Another PD Engineer stresses the value of information and knowledge exchange in Single Sourcing by choice: *Purchasing department looks at certifications and the ppm (product parts per million rejection) levels of suppliers. They are just numbers, things that you tick off on a form. But if the same supplier is not able to provide the information I need, then he is of no use to us. […] Yes, Single Sourcing makes you vulnerable, but at least you know that the product part can be made. Showing it then to other suppliers by way of proof is more effective than showing a drawing* (Chapter 5, Section 5.2.1).

The supplier's Director explains his approach to Single Sourcing: *I am not trying to get orders for all stamping parts of Firm B. For an average stamping part the Purchasing department of Firm B selects two or three suppliers and gives the order to the cheapest one. I am interested only in those product parts to which we can add value, because then I can get a better price. […]. We earn our money by products, but in fact, we are selling knowledge* (Chapter 5, Section 5.2.3). The foregoing comments illustrate that Firm B is highly pragmatic in its choice of sourcing strategies: multiple sourcing is seen as an 'ideal' but on the whole, Single Sourcing has been found to work better.

Single Sourcing in Firm D

Firm D follows a Single Sourcing, and occasionally, a sole sourcing strategy. There are two explanations for this. One explanation lies in the history of the firm. Firm D used to be a vertically integrated organization which is tantamount to Single Sourcing. When the former manufacturing facility of Firm D became an independent firm, it remained located on the same site as Firm D, and continued as a preferred supplier of Firm D. The second explanation for the Single Sourcing strategy lies in the technological complexity of Firm D's products, and the small volume orders.

The (Design) Engineer explains why dual or multiple sourcing is not always an option: *Of course, it would be good to have a second source for a number of product parts. But that means that you would have to order the product parts from both suppliers. If you don't do that, then you cannot expect any cooperation from the suppliers because of the small volume that we purchase and the manufacturing costs involved. The suppliers want commitment. For us, as manufacturers of small volume special products, dual sourcing is not always an option. I believe our firm has a long list of product parts for which we have only one supplier; often this is because there is no other supplier* (Chapter 7, Section 7.2.1). Thus, Firm D follows the strategy of Single Sourcing by necessity. One consequence of the strategy of Single Sourcing by necessity is that the relationships of Firm D with supplier firms are longstanding, going back 20-30 years. But Firm D also experienced the risk of Single Sourcing when a supplier firm of twenty years had decided overnight to discontinue the production of a product part for Firm D. The new Management of the supplier firm objected in principle against supplying products to a Defence manufacturer, such as Firm D.

At one time, Firm D came close to multiple sourcing when it briefly considered using COTS (commercial off-the-shelf) components in its products. The issue arose because a lot of electronic components that Firm D used became available as COTS (commercial off-the-shelf) products. However, customizing these products to meet the requirements of the Firm D's customers can be problematic (e.g., the technical upgrade of an air drier described in the case report of Firm D in Chapter 7).

The (Design) Engineer explains: *You can certainly reduce the costs that way. However, it is important to have the product documentation in order. The supplier of a COTS product gives a guarantee, but if you make the product compliant with your own (military) specifications, the guarantee no longer applies. So you have to document the specifications of the product at the point of purchase, and then add to it your own document with details about the changes that you have made, and the qualification tests. The result is a new product with a new product number* (Chapter 7, Section 7.2.1).

The Purchasing Product Manager comments: *In principle I am in favour of using COTS products, but I have learned from experience that COTS products are only of limited use to us. They always need to be improved one way or another because we want to have something extra to offer to our customers. The Commodity Team Leader concurs: At the time it was a trend to change over to COTS product parts as much as possible in order to reduce production costs. The risk for us operating in the Defence industry is that COTS products do not comply with the military specifications that our customers require, and that means that we have to qualify the product ourselves* (Chapter 7, Section 7.2.3).

Single Sourcing is nevertheless recognized as a means for exchanging information and knowledge.

The (Design) Engineer describes what he expects from a preferred supplier: *They must be prepared to share their knowledge, and the same applies to us, so that together, we bring our knowledge to a new level. I suspect that you are more likely to get that kind of relationship with a single source supplier because then the supplier has the certainty that he gets the order* (Chapter 7, Section 7.2.1). The placing of the order is, however, in the hands of the Commodity Team of the Purchasing department of Firm D, and not in the hands of the (Design) Engineers. This makes Single Sourcing subject to negotiation between Purchasing and (Design) Engineers.

BOX 8.2

REFLECTIVE COMMENT on the Multicase Theme of SINGLE SOURCING based on advantages and disadvantages listed in Table 8.6.

Historically, the benefits of Single Sourcing have only been argued from the costs and product quality perspective. The lower costs of ordering were the result of advanced information about production schedules, and of placing large volume orders with one supplier, thereby getting discounted prices. The improved product quality stemmed from close cooperation, whereby manufacturing problems could be countered quickly and effectively. In contrast, the present thesis' evidence points out the knowledge benefits of Single Sourcing.

As firms increasingly need to source knowledge for NPD from outside the firm, the role of suppliers in the firm's product development takes a new direction. The enhanced awareness among the customer firms of the suppliers' knowledge potential is given by the fact that product development through knowledge sharing, more so than product and production costs, has become the new mode of achieving a competitive advantage. The suppliers are the nearest and most experienced information source that a firm has access to. The firms can relate to their suppliers because they have a common knowledge base.

Reciprocity is the touchstone by which the business partners evaluate the worth of their relationship. Giving support to one another when needed, such as 'assuming responsibility' in troubleshooting situations. The case evidence suggests that even though the risks of Single Sourcing are acknowledged, they are not deterrent enough when compared to the benefits of Single Sourcing. The decision concerning Single Sourcing by choice or Single Sourcing by necessity is influenced by the type of industry to which the firm belongs, and by the order volume that the firm purchases. In the case of Firm A, the choice for multiple sourcing is understandable given the number of suppliers available (this is also reflected in the number of interviewees from supplier firms in the present study; six in total). The policy of Firm A to avoid Single Sourcing as much as possible fits in with the core competency of Firm A, which is to control production costs. Firms B and D adopt the strategy of Single Sourcing by necessity because there are fewer suppliers in their field of manufacturing, and the volume orders are small. Nonetheless, all three firms turn to Single Sourcing by choice whenever the product complexity can benefit from the utilization of supplier's knowledge and expertise.

8.3.3 Physical Objects

In the literature, physical objects that act as information bearers, and which are instrumental in exchanging information and knowledge across professional functions, disciplines, and communities, are usually referred to as boundary objects.

The concept of boundary objects originates from sociology (Star and Griesemer, 1989), but has been extended to the field of design engineering and new product development by Kathryn Henderson (1991) and Paul R. Carlile (2002, 2004, 2005). Other researchers followed (Boland and Collopy, 2004; Hawkins and Rezazade, 2012; Koskinen, 2005; Kreiner 2002; Murphy and Pauleen, 2007; Nicolini et al., 2012; Stompff, 2012).

Henderson (1991) focuses on the interface function of visual communications such as sketches and drawings, and how they facilitate the exchange of information and knowledge among (Design) Engineers. She contrasts the flexibility of sketches and drawings with the rigidity of information systems. Carlile (2002) ascribes three functions to boundary objects:

- representing (boundary objects represent the language shared by individuals using the boundary object);
- learning (boundary objects enable the individuals who use them to learn from one another); and
- transforming (boundary objects enable their users to transform their knowledge to a new level).

The findings of the present thesis revealed that although the (Design) Engineers used boundary objects daily in their work, they did not recognize them as such. Hawkins and Rezazade (2012) had a similar experience:

> *Labelling objects as boundary objects is traditionally an academic activity and not commonly done within organizations. Labelling boundary objects is often an ex-post facto activity applied by scholars to objects that facilitated the overcoming of a knowledge boundary by providing a stable, and sometimes purely mental, artefact to promote coordination.*

The sporadic attention that the case study informants have paid to boundary objects is also evident from the fact that the Salient Issue ‘Physical Objects (as information bearers)’ spontaneously emerged only in two cases, namely in Firm B and Firm C. However, when delving deeper into the coding and categorizing data (covering 42 verbatim transcripts of interviews, field notes and meetings), the salient role of artefacts, such as technical drawings and prototypes, becomes soon apparent. Murphy and Pauleen (2007: 1009) talk about the ‘visible artefacts’ that help the dissemination of the ‘invisible thoughts’. In other words, the visible artefacts help mobilize tacit knowledge. An explanation why the boundary objects were only rarely mentioned in the interviews must be sought in the fact that the function of these visible artefacts was taken for granted.

The case study informants regarded technical drawings, prototypes and such like as a means to an end (i.e., to manufacture the ultimate product). Thus, the process of 'tacitly mobilizing tacit knowledge' (Kreiner, 2002) was regarded as commonplace. So much so in fact, that the informants did not think to mention, for example, the central role of technical drawings in the iterative sense making process between the (Design) Engineers and the supplier's Manufacturing Engineers. The result of this exchange of information and knowledge was that the technical drawings became 100 per cent reliable, and the production could start. To the informants, however, it was simply the way things were done.

Stompff (2012: 285) underlines the pivotal role of physical objects, such as prototypes, when he states: *Take away the prototypes and it becomes impossible to align and coordinate the activities of multidisciplinary teams, thus effectively disabling NPD*. His research on team cognition revealed that nearly as many design cues (i.e., the next steps in design) originated from the interaction with the prototypes as they did from the dialogues with fellow team members (Stompff, 2012: 78). Stompff's confidence in the value of physical objects in NPD leads him to suggest that future research of the design practice should study whether there is a relation between the number of developers required for a product and the number of physical objects and representations deployed during the development of that product (Stompff, 2012: 307).

The next paragraphs will use the combined term 'Physical (Boundary) Objects' in order to reconcile the Salient Issue terminology (derived from the Within-case Analyses) and the terminology of Paul Carlile (2002).

Table 8.7 provides an overview of the use of Physical (Boundary) Objects in Firms A, B, C, and D. For readers' convenience, the Physical (Boundary) Objects, nine in total, are listed in alphabetical order. The utilization of Physical (Boundary) Objects is discussed in terms of their functions of *representing, learning*, and *transforming* (Carlile, 2002).

However, in addition to these three functions, the present thesis wants to make a case for one more function of the Physical (Boundary) Objects, namely, that of *evidencing*. A closer look at SI 11 (Box 5.3, Firm B) and SI 19 (Box 6.4, Firm C) reveals that the Physical (Boundary) Objects not only contain information (i.e., are 'information bearers') but that the Physical (Boundary) Objects also embody, or serve as an evidence of, the intentions and motives that guide the information relationships of their users.

In Firm B (Box 5.3), the Morphological Map has an evidentiary function. It documents the past design solutions, and thus impacts the choices that the (Design) Engineers consider in future projects. The CAD models are an evidence of a particular stage of design.

In Firm C (Box 6.4), exhibiting the Gripper component at trade shows evidences to the world the state of technology of Firm C. The ensuing publicity impacts the willingness of the customer firms to participate in pilot projects and to engage in closer information relationships.

The new function, *Evidencing: the impact of Physical (Boundary) Objects on the information relationships of their users* appears in the last column in Table 8.7.

The next paragraphs discuss the use of the Physical (Boundary) Objects in the Firms A, B, C, and D. The four functions of the Physical (Boundary) Objects appear in the text in italics.

For each firm the analysis opens with an alphabetical list of the Physical (Boundary) Objects found in that particular firm, after which the Physical (Boundary) Objects are discussed, one by one. Given the fact that the case evidence is in places quite detailed, the text works with graphic symbols in order to ensure legibility. Each time a new Physical (Boundary) Object is introduced, the text paragraph is indented, and marked with two asterisks (**).

The Physical (Boundary) Objects in Firm A

The case report of Firm A (Chapter 4) identified the following Physical (Boundary) Objects: the Bill of Materials, Design Standard, Prototypes, Risk Mitigation Plan, and the Trade Studies.

** The Bill of Materials *represents* the customer's choice of product parts. The (Design) Engineers of Firm A *learn* from the Bill of Materials about the customer's preferences and design solutions. The (Design) Engineers can apply this knowledge in another project (*transformation*), or come with a design modification.
The Bill of Materials' *impact on the information relationships* becomes *evident* in the interaction between its prime users, namely, the (Design) Engineers. The Bill of Materials triggers the (Design) Engineers' curiosity and confidence which are *evident* in the searches for alternative design solutions.

** The Design Standard *represents* a preliminary selection of proposed product parts based on the Qualified Product Part List (QPL) that the customer had used in previous projects. The (Design) Engineers of Firm A and the (Design) Engineers of the customer firm have to agree on the Design Standard before the actual project can start. Firm A *learns* from the Design Standard about the product part preferences of the customer firm. Firm A *transforms* this knowledge into proposals in which it recommends the product parts that can be added to the customer's QPL.
The Design Standard's *impact on the information relationship* between the (Design) Engineers of Firm A and their counterparts in the customer firms is considerable. The Design Standard *evidences* to the customer firm the capability of Firm A to suggest new and/or cheaper solutions, hereby increasing the customer's trust in Firm A as a knowledge partner.

** The Prototypes *represent* the manufacturability of a product concept. The prototypes described in the 'Sounding board' example (Chapter 4, Section 4.2.1) are made by diverse supplier firms according to the specifications for a yet-to-be-developed product part. The request for prototypes comes from a Firm A's customer and the (Design) Engineers of Firm A communicate the wishes of the customer firm to the Sales Engineers of supplier firms. The (Design) Engineers of both Firm A and the customer firm *learn* from the testing of prototypes how to improve the product concept further. The supplier firms that make the prototypes do not know the identity of the customer firm, but they *learn* through the specifications about the current needs and trends in the industry. The knowledge gained from testing can lead to design modifications, or to different use of material (*transformation*). The prototypes' *impact on the information relationships* between the (Design) Engineers of Firm A, the (Design) Engineers of the customer firm, and the supplier's Sales Engineers is *evident* from the goodwill that marks the relationship. When the (Design) Engineers test the prototypes at cost price (i.e., the number of engineering hours), they show goodwill towards the customer firm. The go-between role that the (Design) Engineers of Firm A fulfil between the customer and supplier firm is also a sign of goodwill, because the (Design) Engineers allow the customer firm to benefit from their knowledge of the supply market. The selection of a particular supplier for the making of prototypes raises this supplier's expectations that, should the product development go ahead, the supplier firm would be asked to manufacture the product parts. By providing the prototypes, the supplier firm signals its goodwill towards the project.

** The Risk Mitigation Plan *represents* a list of potential risks that could arise from disruptions in supply. It is prepared by the Material Review Board of Firm A in which both (Design) Engineers and Purchasers participate. The Material Review Board draws on (*learns from*) the experiences of past projects and on the Firm A's knowledge of supply market. This knowledge is *transformed* into a list of possible product part replacements. The Risk Mitigation Plan's *impact on the information relationships* is *evident* from the intense collaboration and sharing of knowledge between the (Design) Engineers and Purchasers during the preparation of the Plan.

** The Trade Studies *represent* on-going comparative tests of product design concepts found on the market. The Trade Studies are continually compiled by the (Design) Engineers of Firm A. The Trade Studies *represent* an accumulation of knowledge gained by Firm A through testing, and this knowledge can be accessed (*learned from*) by Engineering and Purchasing staff. The *transformation* of the Trade Studies takes the form of proposals that Firm A submits to customers, containing recommendations on the selection of product parts. The Trade Studies' *impact on the information relationship* between the (Design) Engineers of Firm A and supplier and customer firms is *evident* in two ways. First, the Trade Studies *evidence* the Firm A's competency as a knowledge provider. Secondly, the Trade Studies intensify the information relationship with the supplier's Sales Engineers who frequently provide (free) samples for the Trade Studies thereby providing *evidence* about the usability of supplier's products.

Table 8.7 Physical (Boundary) Objects in Firms A, B, C, and D.

Physical (Boundary) Objects (firm)	Functions of Physical (Boundary) Objects			
	Representing	**Learning**	**Transforming**	**Evidencing:** impact on information relationships of the users
AHP surveys **(B)**	Customers' requirements	Customers' preferences	Prototypes	AHP surveys evoke trust. Evidence the robustness of market research of Firm B. Encourage customer firms to make time available for AHP surveys, thus providing Firm B with valuable feedback.
Bill of Materials **(A)**	Customer's choice of product parts.	Customer's preferences and design solutions.	Applying design solutions elsewhere	Triggers the (Design) Engineers' curiosity and confidence which are evident in the search for alternative design solutions.
Design Standard **(A)**	Proposed product parts	Customer preferences about product parts.	Additions to QPL.	Increases trust in Firm A. Evidences to the customer that Firm A's capability as a knowledge partner.
Engineering Change Proposal **(D)**	State of supplier knowledge.	Qualification tests.	Product is qualified, or the process of Engineering Change Proposal begins anew	Evokes trust in the expertise of the supplier firm. This is evidenced from the way the proposal is handled.
Morphological Map **(B)**	Visual compilation of manufacturing solutions based on literature, patents, and past projects. An accumulation of Firm B's knowledge.	Manufacturing solutions that worked in the past projects of Firm B.	Re-use of tried out solutions in new projects.	Evidences past manufacturing solutions. Facilitates communication and brings trust into the collaboration between R&D Engineers and PD Engineers.
Prototypes **(A)**	Manufacturability of the design concept.	Testing. of prototypes	Modifications in design concept.	Bring about goodwill among prototype users.
Prototypes **(B)**	Product parts with 'mission critical' dimensions.	Testing .of prototypes	Design modifications	Evoke trust between PD Engineers and the (Design) Engineers of supplier firm, evident from joint problem solving.
Prototypes **(C)**	Pilot stage of product development exhibited at trade shows.	Testing of prototypes, videos. Feedback from the public and industry.	Commercial product or discontinuation of the project.	Testing of prototypes in pilot projects is evidence of trust and deepening of information relationships between the pilot participants.
Risk Mitigation Plan **(A)**	Risks in disruption of supply.	Experience from past projects.	Proposal for product part replacements.	Exemplifies the need for close collaboration between Purchasers and (Design) Engineers.
Technical drawings **(B)**	Proposed product dimensions and tolerances.	Technical drawings are modified. Accuracy and reliability of drawings is improved.	Modifications end when the drawings are 100% reliable.	Impacts supplier's productivity and product quality. Modifications in drawings serve as evidence of trust in the capabilities of people involved.
Technical drawings **(C)**	Customer's drawing represents requirements for product parts.	The Sales Engineer makes a new drawing which includes recommended product parts.	The drawing & recommenda-tions are accepted by the customer .	Evidence the trust building between the Sales Engineer and the customer firm. If successful, results in repeated sales.
Trade studies **(A)**	On-going comparative tests of product parts currently on the market. Accessible accumulation of knowledge.	Low cost design solutions.	Recommendati ons to the customer on the product selection.	Evidence to the competence of Firm A as a knowledge provider. Suppliers make free samples of product parts available thereby evidencing the usability of their products.

<u>The Physical (Boundary) Objects in Firm B</u>

The case report of Firm B identified the following Physical (Boundary) Objects: the AHP (Analytic Hierarchy Process) surveys, Morphological Map, Prototypes, and the Technical drawings.

<u>**</u> The AHP (Analytic Hierarchy Process) Surveys *represent* a compilation of customers' requirements. The AHP surveys are carried out regularly by R&D Engineering and the Sales department of Firm C. The R&D Engineers and Product Development (PD) Engineers *learn* from the AHP surveys about the customers' preferences and wishes with regard to product features, functions, electrical and mechanical performance, and costs. Knowledge thus gained is incorporated (*transformed)* into prototypes in order to establish whether the product can be mass-produced.

The AHP surveys' *impact on the information relationship* between the (Design) Engineers of Firm B and customer firms consists of demonstrating to customers the robustness of the market research of Firm B. The AHP surveys *evidence* the seriousness with which Firm B takes customers' wishes into consideration. This in turn evokes trust and encourages the Purchasers and the (Design) Engineers of customer firms to participate in the surveys (some 80 per cent of customer firms agree to take part), thus providing Firm C with a valuable feedback.

<u>**</u> The Morphological Map developed by R&D Engineers of Firm B *represents* a visual compilation (a kind of memory) of manufacturing solutions based on the literature, patents, and past projects of Firm B. The Morphological Map is supported by a back-up collection of product samples. Thus, Morphological Map *represents* an accumulation of Firm B's knowledge, and makes this knowledge accessible and usable. The R&D Engineers and PD (Product Development) Engineers *learn* from the Morphological Map about the manufacturing solutions that had worked well in the past. The Map is periodically updated as new solutions become known. The *transformation* of the knowledge from the Morphological Map results in re-using the tried out solutions in the Firm B's new projects.

The Morphological Map's *impact on the information relationships* within Firm B is *evident* from the way it brings trust into the collaboration and the exchange of information and knowledge between these two departments. The Morphological Map has an *evidentiary* function in that it documents past manufacturing solutions and thus *impacts* future design choices.

<u>**</u> Technical drawings *represent* the technical functions and requirements for product parts, including the proposed dimensions and tolerances. The drawings are made by the PD Engineers of Firm B and are subsequently submitted to supplier firms for assessment of the manufacturability of the product parts. Thus begins a series of exchanges of information and knowledge (*learning)* between the PD Engineers of Firm

B and the Manufacturing Engineers of the supplier firm. The exchanges result in modifying the drawings to increase their accuracy and reliability. The modifications are complete when the drawings are 100% reliable (*transformation).*

The technical drawings' *impact on the information relationship* between the PD Engineers of Firm B and the Manufacturing Engineers of the supplier firm is considerable. The technical drawings serve as *evidence* of the capability of the parties involved. Ultimately, the outcome of the information relationships becomes *evident* in the supplier's productivity and product quality.

** Prototypes *represent* product parts with 'mission critical' dimensions (e.g., dimensions that could cause production problems). This was the case with some parts of the steel casing/housing which required forming that exceeded the conventional metal forming limit. Through testing of prototypes the (Design) Engineers and the supplier's Manufacturing Engineering explored (*learned about)* the manufacturing possibilities. The prototype tests resulted in design modifications (*transformation*).

The prototypes' *impact on information relationships* between the PD Engineers and the supplier's Manufacturing Engineers has consequences for the information relationships at the firm level. Both firms wish to avoid the risk of production stoppages, but that does not prevent Firm B from being a demanding customer. The supplier's willingness to go the extra mile, however, is rooted in the *evidence* of how information relationships functioned at the micro-social level of the firm. The (Design) Engineers and the Manufacturing Engineers must be able to trust that any eventual problem can be solved together.

The Physical (Boundary) Objects in Firm C

The case report of Firm C identified the following Physical (Boundary) Objects: Prototypes and Technical drawings.

** The prototypes exhibited at world trade shows, such as the prototypes of the Gripper component, *represent* the pilot stage of product development. Exhibiting at world trade shows can be seen as a *learning* experience. The (Design) Engineers of Firm C *learn* from the feedback they receive from the public and the industry about the market potential of the product concept. The next *learning* experience are the pilot tests with the customer firms involving the exchange of videos, test results, and several versions of improved prototypes. The *transformation* of this knowledge leads either to the commercialization of the product concept, or to the discontinuation of the project.

The prototypes' *impact on the information relationships* between the (Design) Engineers of Firm C and the customer firms is best *evidenced* from the pilot projects which deepen the information relationships between the customer and supplier firm. Trust and exchange of confidential information underpin the relationship.

** Technical drawings *represent* customer's requirements for a product part. On the basis of this technical drawing, the Sales Engineer can make a new technical drawing from which the customer firm can *learn* which product parts of Firm C meet the stated requirements, and could be applied (*transformed*) in customer's products. If successful, the technical drawings' *impact on the information relationship* between the Sales Engineer and the (Design) Engineers of the customer firms is *evident* in the building of trust, repeated calls for advice, and sales.

The Physical (Boundary) Objects in Firm D

The case report of Firm D identified one Physical (Boundary) Object: the Engineering Change Proposal.

** The Engineering Change Proposal *represents* the state of supplier knowledge. It is made by the Account Manager of the supplier firm and concerns an upgrade of compressors in air driers. The Commodity Team of Firm C reviews the proposal and instigates qualification tests at the site of Firm D. The supplier firm is invited to be present. The Commodity Team *learns* from the tests whether to proceed with the qualification of the upgraded product part (*transformation*), or whether the process of Engineering Change Proposal needs to start anew.

The Engineering Change Proposal's *impact on the information relationship* between the customer and supplier firm is *evidenced* from trust with which Firm D deals with the supplier's proposal. The Account Manager of the supplier firm needs first to convince the Commodity Team of Firm D of the need for an upgrade. The Commodity Team must be able to trust the expertise of the supplier firm.

BOX 8.3

REFLECTIVE COMMENT on the Multicase Theme of PHYSICAL (BOUNDARY) OBJECTS based on the functions of boundary objects listed in Table 8.7.

Viewed from the perspective of information relationships, the functions of representing, learning, and transferring can be described as the 'enabling properties' of Physical (Boundary) Objects. They are the 'action' components of the boundary objects because they make tacit knowledge communicable to others. - The last column in Table 8.7 addresses the function of evidencing, that is, how the physical (boundary) objects impact the information relationships of their users. Here the case evidence shows that the Physical (Boundary) Objects produce trust and goodwill towards and on behalf of their users. The principle of "Seeing is believing" can be said to be the guiding force behind the function of evidencing of the Physical (Boundary) Objects.

8.3.4 Trust

The Multicase Theme of Trust is the fourth and last Multicase Theme that the present thesis has identified. It is worth noting that the Multicase Theme of Trust emerged only after a third round of data analysis, when the six Salient Issues that remained 'single'(i.e., did not fit into any of the three Multicase Themes) were again examined for their relevancy across the four firms.

A tentative explanation as to why Trust as a Salient Issue (and subsequently as a Multicase Theme) did not emerge earlier could be the fact that in the case reports (Chapters 4-7), the informants only rarely raised the issue of trust explicitly. And when they did, the unequivocal claims, '*they trust us',* came mostly from the informants of supplier firms. By comparison, the informants of customer firms *'doubted'* the suppliers' integrity or capability, or they simply made use of the Non-Disclosure Agreements to prevent the leakage of information. There were never outright statements of distrust. Thus, it was only on closer examination of the data that the implicit presence of trust in the informants' interactions with others became apparent. This finding is consistent with the research by Lewis and Weigert (1985: 968-969) who view trust as, first and foremost, a social phenomenon, and involving two parties:

> *The primary function of trust is sociological rather than psychological, since individuals would have no occasion or need to trust apart from sociological relationships. […] Trust must be conceived as a property of collective units (on going dyads, groups, and collectivities), not of isolated individuals. Being a collective attribute, trust is applicable to the relations among people rather than to their psychological states taken individually.*

Mayer et al. (1995) and Schoorman et al. (2007) have pursued the dyadic character of trust further. Their Integrative Model of Dyadic Trust (Figure 8.2) places the dyadic trust relationships in an organizational setting and defines the factors by which the two specific parties, a trusting party (a trustor) and a party to be trusted (a trustee) perceive trustworthiness. The model has been validated by Serva at al. (2005), and cited by Google Scholar over 7,000 times.

What makes the Integrative Model of Dyadic Trust interesting for the present thesis is the way the model makes a distinction between trust and risk: "the need for trust only arises in a risky situation" (Mayer et al., 1995: 711).

The definition of trust by Mayer et al. (1995: 712) reads as follows:

> *Trust is the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control the other party.[…] Making oneself vulnerable is taking risk. Trust is not taking risk per se, but rather it is a willingness to take risk.*

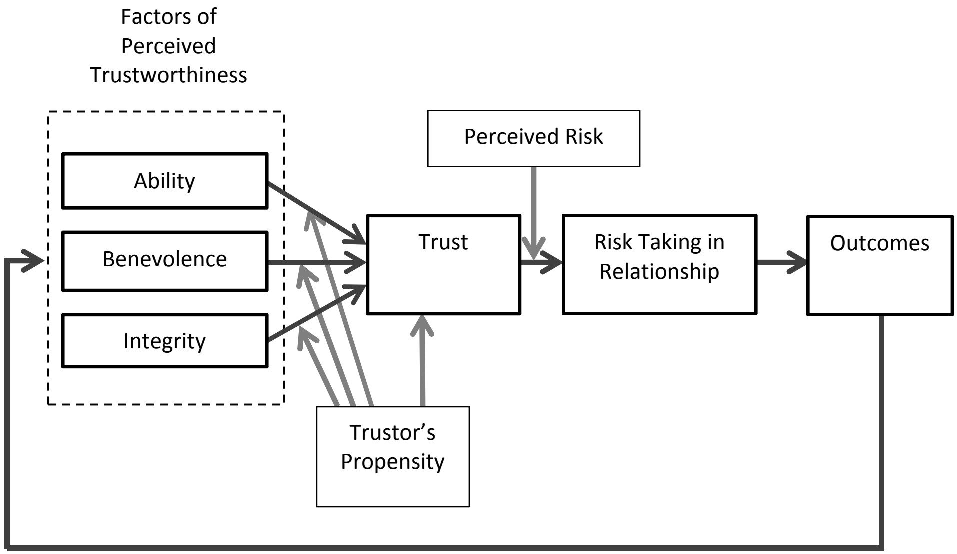

Figure 8.2: Integrative Model of Dyadic Trust (Mayer et al., 1995: 715)

Mayer et al. (1995) and Schoorman et al. (2007) point out that trust as such is not visible. Visible are only the reciprocal actions of trustors and trustees, or their risk taking behaviours.

In the context of the information relationships between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers in customer and supplier firms, the trusting action is the utilization of supplier information and knowledge. At the level of the firm, the utilization of supplier information and knowledge represents the outcome of a risk taking relationship between the customer and supplier firms which originates in the customer firm's willingness to be vulnerable by involving suppliers in its NPD projects.

Earlier research on the interconnections of information exchange and trust (Denize and Young, 2007) positioned information exchange at the heart of business relational development, and used surveys of diverse types of information exchanges to explain the evolution of trust relationships at the inter-firm level. The present thesis takes a different approach.

The Integrative Model of Dyadic Trust, shown in Figure 8.2, is used to examine the case study evidence with regard to the dyadic information relationships involving the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers, at the micro-social level of the four focal firms. Each component of the model is discussed in turn, and placed in the context of the four case reports.

The five components of the Integrative Model of Dyadic Trust (Mayer et al., 1995), shown in Figure 8.2, are:

- factors of perceived trustworthiness;
- trustor's propensity;
- perceived risks;
- trust and risk taking relationships; and
- outcomes.

The feedback loop in Figure 8.2 indicates that the outcomes of the risk taking relationship influences the trustee's perceived trustworthiness.

Factors of perceived trustworthiness

An observation that needs to be made at the outset concerns the starting point for trust. Trust relationships are known to grow and develop (Lewicki and Bunker, 1996), but in the context of the present thesis, the trust relationships do not begin at time zero. The simple fact that all focal firms are, or deal with, the so-called 'preferred suppliers' implies that the firms have already arrived at 'institution-based trust' and 'situational normality' in their relationship. This means that agreements, contracts, guarantees and other safeguarding measures are in place allowing the employees of the respective firms to anticipate success when they enter into dealings with one another (McKnight et al., 1998). For the purposes of the present study, it means that two of the three factors of perceived trustworthiness - ability and integrity - can be taken as a given. The ability (i.e., the expertise of the trustee in the business domain of the trustor), and the integrity (i.e., a set of principles of the trustees that the trustor finds acceptable) of the preferred suppliers have been purposively checked and screened: the customer and supplier firms participating in the present thesis are trading partners, with an assumed benevolence in consequence.

The real test of benevolence, the third factor of trustworthiness, takes place at the micro-social level of the firm, through interpersonal relationships and experience of the (Design) Engineers, Purchasers, and Sales Engineers of customer and supplier firms, when interacting with each other at the fuzzy front end of NPD. For the (Design) Engineers, Purchasers, and Sales Engineers the factor of benevolence is the only factor of the three factors of trustworthiness that they can influence through their own behaviour.

Therefore, in studying dyadic information relationships, the present study pays special attention to benevolence. This separate focus on benevolence is consistent with the argumentation of Mayer et al. (1995: 720-721) who, in defining the components of their Integrative Model of Dyadic Trust, stress the interrelationship of the three factors of perceived trustworthiness:

> *Ability, benevolence, and integrity are important to trust, and each may vary independently of the others. This statement does not imply that the three are unrelated to one another, but only that they are separable.[…] If ability, benevolence, and integrity were all perceived to be high, the trustee would be deemed quite trustworthy. However, trustworthiness should be thought of as a continuum, rather than the trustee being either trustworthy or not trustworthy. Each of the three factors can vary along a continuum.*

Mayer et al. (1995: 718-719) define benevolence as follows:

> *Benevolence is the extent, to which a trustee is believed to want to do good to the trustor, aside from an egocentric profit motive. Benevolence suggests that the trustee has some specific attachment to the trustor […]. Benevolence is the perception of a positive orientation of the trustee toward the trustor.*

Interesting in the foregoing definition is the reference to an 'egocentric motive'. For it could be argued, that of the three functional areas, i.e., (Design) Engineers, Purchasers, and Sales Engineers, the function of Sales Engineers in particular operates from an egocentric motive. After all, the performance of Sales Engineers is judged by the sales turnover they achieve. The findings of the present thesis, however, demonstrate that such a conclusion would be premature.

The evidence from the case reports indicates that when the Sales Engineer acts as Knowledge Worker (Darr, 2002, 2003, 2006), as for example, in the development of a Hand Tool in Firm A (Chapter 4, Section 4.2.1), or in the case of the consultancy work of the Sales Engineer at the Regional Subsidiary of Firm C (Chapter 6, Section 6.2.2), or when the supplier firm considers itself as 'selling knowledge through products' (Chapter 5, Section 5.2.3), then the sales turnover, although still important, comes (temporarily) in the second place. One Sales Engineer describes the quandary facing the suppliers' Sales Engineers as follows: *Of course, in the end we want to sell our products. But at the same time our technology team tries to orient the mind of each team member to the needs of the market, to find technical solutions* (Chapter 4, Section 4.1.2).

Table 8.8 illustrates with the help of a few selected quotes from the case reports (Chapters 4-7), the role that benevolence plays in the utilization of supplier information and knowledge.

Table 8.8 Manifestations of benevolence in relation to the utilization of supplier information and knowledge in the FFE of NPD

Firm	Quotes from the case reports
A	Chief (Design) Engineer: *They [the supplier firm] have a more positive attitude to this kind of questions. You can discuss a problem with them without having to take out your wallet first, as is the practice with the suppliers who look only for commercial benefits* (Chapter 4, Section 4.2.1).
B	(Design) Engineer: *And that's what makes this particular supplier attractive: they enjoy the challenge; they like to have an opportunity to tackle new problems. And if something cannot be done, they come with good arguments. They consult and deliberate with us* (Chapter 5, Section 5.2.1).
C	Sales Engineer: *They [Design Engineers of the customer firm] invite me and say: 'We know that you have good ideas and that's why we want to talk with you.* (Chapter 6, Section 6.2.1)
D	Commodity Team Leader: *You have to make allowances, give room to Programme (Design) Engineers to ask the supplier firm: 'How much would it cost if we were to do it this way?' And afterwards, the (Design) Engineers come to us and we formalize the agreements with supplier firms together. You have to show some flexibility otherwise you cannot operate as a company.* (Chapter 7, Section 7.2.2).

Trustor's propensity

Mayer et al. (1995) stress that when defining trust a distinction needs to be made between a trustee's characteristics (ability, benevolence and integrity), and a trustor's characteristics (i.e., the trustor's propensity to trust), the personal willingness to trust others.

In the four focal firms of the present thesis, the trustor's propensity to trust at the level of (Design) Engineers, Purchasers, and Sales Engineers was found to be subordinate to the business environment (i.e., the type of industry, in which the firms operate). For example, in the case of Firm A, the relationship with supplier firms is governed by the fact that Firm A has many suppliers to choose from. In contrast, Firm D needs to cooperate closely with a limited number of suppliers because of the small order volumes, and the technical complexity of product parts.

These circumstances are also mirrored at the micro-social level of the firm and affect the frequency and readiness with which individuals participate in joint NPD projects. Thus in Firm A, the Integrated Product Team (Chapter 4, Section 4.2.1) which includes the supplier's Sales Engineer, is more an exception than a rule, given that the Firm A's relationship with suppliers focuses primarily on supplier performance. By comparison, in Firm D, the cooperation with suppliers may start quite early and involve commissioning suppliers to carry out feasibility studies on the costs and manufacturability of proposed projects. (Chapter 7, Section 7.1).

The Trustor's propensity to trust increases with time. The choice of Single Sourcing made by Firm B may be explained by the fact that the suppliers of long standing are cognisant with the way Firm B organizes its projects, and Firm B perceives this supplier's know-how as a means to save time in the run up to the project. Here the supplier knowledge is procedural. In the case of Firm C, itself a preferred supplier, the reason why the customers turn to Firm C for advice is because of the Firm's C reputation as an innovative firm, and customers' positive experiences in the past. *Our firm may use other suppliers for series parts but for our (product) development we prefer the Regional Subsidiary (of Firm C). Besides, we don't want to change the winning team* (Chapter 6, Section 6.2.2). The National Subsidiary of Firm C often gets a carte blanche from its customers: "*You know much better than we do which product components we need. Our problem is…. Come with a proposal.*" (Chapter 6, Section 6.2.1).

However, sometimes there is no time for the gradual building of trusting relationship. The subordinate role of the trustor's propensity to trust, as shown in Figure 8.2, is particularly manifest in ad-hoc NPD teams. Members of the ad-hoc teams cooperate with one another on the basis of 'swift trust' (Mayerson et al., 1996; Robert Jr. et al., 2009), that is, trust that is not based on personal knowledge of the team members' past behaviour (e.g., ability, integrity, and benevolence) but on swift category processing (e.g., assessing team members by their gender, profession, organizational role, or by using a third party recommendation, etc.). The urgency of the job takes priority over assessing team members' trustworthiness. The temporary project teams of technical specialists at Firm D would be an example of 'swift trust'.

As soon as the project team reaches the stage of the *'first of a series'* of the new product, the Production takes over, the Project Team is dissolved, and the team members are assigned to another project.

Perceived risk

The perceived risk in the Integrative Model of Dyadic Trust (Figure 8.2) represents a contextual factor that moderates the link between trust and the risk taking relationship. The level of trust based on the trustor's characteristics (propensity to trust) and the trustee's characteristics (ability, benevolence, integrity) may be constant, but the context in which the two parties find themselves is subject to changes which affect the trustee's assessment of risks, and thereby also the trustee's risk taking behaviour.

The case reports (Chapters 4-7) show that the four participating firms perceive the risks of NPD situations differently when they act as suppliers, from when they act as customers. For example, when Firm D (in its role as customer) was first reminded by its supplier that an upgrade of air driers was called for, nothing much happened, as the supplier's Account Manager recollects:

The Technical Specialist of the Commodity Team (of Firm D), our Technical Specialist and I have discussed air driers many times in the past, but nothing ever came out of it. We talked about how we could make the air driers simpler, smarter, and standardized. Many product parts were getting in short supply or were becoming obsolete. We have an obligation towards Firm D to supply product parts that are always FFF (fit form function) compliant, but finding alternatives for FFF product parts requires extra effort. That's why we wanted to review the air drier in its entirety. However, the project itself started much later, in 2003. Firm D requested us to look at the specifications of the old model and to come with a proposal on how to make the air drier smarter by integrating new components. And of course, the new air drier had to be cheaper. Firm D set the costs saving target at 40%, but the ultimate costs reduction that we managed to achieve was around 25%. (Chapter 7, Section 7.2.3). In addition to the cost reduction drive, Firm D had still another reason for requesting the supplier firm to submit proposals for the upgrade of air driers: by the year 2003, Firm D (in its role as supplier) had a concrete customer for the air driers.

Similar switching with respect to the risk perception can be found in the case reports of the other three firms as well. Whenever a NPD project involves supplying product parts to a concrete customer, time schedules and order volumes become critical. For example, the Regional Subsidiary of Firm C turned down a request from a customer firm to develop a product part because the development of the proposed product part would take too long, and was expected to result only in a few sales (Chapter 6, Section 6.2.2).

In contrast, when the firms initiate NPD projects as customers, as part of their own research, the NPD projects can span several years, with the exchange of knowledge as an important by-product. The Director of Corporate Design in Firm C describes the risk avoidance element behind the bionic design projects as follows:

*When you see how much testing is required and how long it takes before producing a product that meets our quality criteria; it's really very expensive. When we do tests through a bionic design project, and there is little interest in the product concept, it's not a problem. We may return to it in five years' time. (*Chapter 6, Section 6.1.1). Similarly, the development of Tooling Machine in Firm A (Chapter 4, Section 4.1.2) took several years to complete. The project had as its goal to avert the risk that Firm A might lose its competitive advantage. The project involved co-location of the supplier's (Design) Engineers in Firm A in order to analyse the production process of Firm A. The supplier firm signed a Non-Disclosure Agreement.

Trust and risk taking relationship

The Integrative Model of Dyadic Trust (Figure 8.2) makes a distinction between trust and the risk taking relationship. Mayer et al. (1995: 724) motivate the distinction as follows:

> *One does not need to risk anything in order to trust, however one must take a risk in order to engage in trusting action.*

In the context of the information relationships between the (Design) Engineers, Purchasers, and Sales Engineers, making such a distinction is helpful in understanding why a customer's trust in the ability, benevolence, and integrity of a supplier firm does not automatically lead to the utilization of that supplier firm's information and knowledge. The case evidence suggests that more than trust alone is involved.

The case reports (Chapters 4-7) point towards the importance of the relationship that the supplier's Sales Engineer, in his role as Knowledge Worker (Darr, 2002, 2003, 2006), needs to maintain with the (Design) Engineers and Purchasers of the customer firm. The task of the supplier's Sales Engineer as Knowledge Worker is to facilitate the exchange of information, that is, to bring about the 'trusting action' between his/her firm and the customer firm in the form of the utilization of supplier information and knowledge. However, before any exchange of information and knowledge can take place, the Sales Engineer must first identify the potential recipients who would be interested in the supplier expertise, and to establish working relationships with them. The case reports show that for such working relationships to produce results, the essential ingredients are trust, knowledge, and social relationships.

Trusted weak ties

To examine and understand the social relationships in the exchange of information and knowledge between the (Design) Engineers, Purchasers, and Sales Engineers of customer and supplier firms, the concept of trusted weak ties could be useful.

The concept of trusted weak ties (Levin and Cross, 2004) bears similarity to the Integrative Model of Dyadic Trust (Mayer et al., 1995) in that it also underlines the importance of benevolence and competence/ability in the exchange (i.e., dyadic) relationships. Whereas the Integrative Model of Dyadic Trust (Mayer et al., 1995) focuses on the antecedents and outcomes of trust, the concept of trusted weak tie focuses on the relationships between the trustor and the trustee during their interaction and the role of trust therein. The interaction constitutes an exchange of information and knowledge.

The concept of trusted weak tie is derived from Mark Granovetter's theory of the Strength of Weak Ties (Granovetter, 1973, 1982). The theory posits that weak ties (temporal interpersonal relationships) are better equipped than strong ties (close interpersonal relationships) to provide access to non-redundant (i.e., novel and diverse) information. The findings of Levin and Cross (2004) extend this research by showing that when weak ties operate in the environment of benevolence-and-competence based trust (i.e., in the environment in which the information source is perceived as trustworthy, benevolent and competent), the weak ties take on the properties of strong ties, such as sharing tacit knowledge and enabling learning. In such situations, in the coinage of Levin and Cross (2004), weak ties become *'trusted weak ties'*.

The evidence from the case reports (Chapters 4-7) suggests that when the supplier's Sales Engineer is perceived by the (Design) Engineers of the customer firm as knowledge worker (i.e., someone who provides and facilitates knowledge exchange), the ensuing information relationships take place in the environment of benevolence-and competence based trust. Such situations arose in Firm A in connection with the development of Hand Tool, the Integrated Product Team, or in the case of identifying new supplier technologies that resulted in joint product development. Other examples are the development of steel housing/casing in Firm B, the pilot projects on the Gripper component in Firm C, or the upgrade of air driers in Firm D.

Outcomes

In the Integrative Model of Dyadic Trust (Figure 8.2), the outcomes of trust are the results of the risk taking relationship between the trustor and the trustee. The success or failure of these outcomes influences the trustor's perception of the trustee's trustworthiness in the future (the feedback loop in the Model).

In the context of the information relationships between the (Design) Engineers and the Purchasers of customer firms and the Sales Engineers of supplier firms, the outcome of a risk taking relationship is the utilization of supplier information and knowledge by the (Design) Engineers and Purchasers of the customer firm.

The case reports (Chapters 4-7) indicate that the utilization of supplier information and knowledge can better be described as a process rather than a single action which is automatic and immediate. The case evidence shows that when the (Design) Engineers and Purchasers of customer firms enter into a risk taking relationship with the supplier's Sales Engineers, the actual utilization process consists of two phases: adoption and implementation.

The two phases are best illustrated by the comment made by a Senior Design Engineer about invitations that he regularly receives from the suppliers' Sales Engineers to visit the supplier's manufacturing plants: *I learn from it. Sometimes the products are handy, and you can use them, sometimes you just thank for the information. But it's always good to know what's available.* (Chapter 4, Section 4.2.1).

The comment makes clear that the adoption and implementation of supplier information are not sequential acts. The implementation depends on whether or not the supplier knowledge is 'actionable', that is, leads to immediate progress on a current assignment, or project (Cross and Sproull, 2004). Moreover, the case evidence does not show any temporal link, that is, a time frame, within which the adoption and implementation take place. In this sense, the case evidence contradicts the literature on the utilization of knowledge in management and marketing which places the utilization of knowledge in the context of sequential time-ordered information processing (Moeneart et al. 2000; Veldhuizen, 2008).

An explanation of this difference may be the character of the design work which, as Van Aken (2005: 382) points out, consists of two human action systems: one producing design and one producing the artefacts on the basis of that design. In consequence, the FFE of NPD ends with a project brief, which may or may not lead to the implementation of the proposed project.

The case evidence shows that the time-gap between the adoption (as in 'knowledge awareness') and the implementation of the latest supplier technology can be both indeterminate and uncertain. It is worth noting that the time-gap is, however, consistent with the theory of Innovation Diffusion (Rogers 1983). The theory defines diffusion as a special type of communication in which the information that is exchanged is concerned with new ideas (new as perceived by the recipient), and is communicated through certain channels, over time, among the members of a social system (Rogers, 1983: 11-17). The newness of innovations, as perceived by recipients, helps explain the different time length between adoption and implementation.

In the context of the present thesis, the time gap between the adoption and implementation is, for example, evident in the practice of Automation Days that the National Subsidiary of Firm C organizes for its customers, or the Supplier Days coordinated by the Purchasing Department of Firm A. In both events, the exchange of information and knowledge is informal, and the utilization supplier knowledge is optional. Another explanation of the time gap may be that the adoption of new ideas about technology does not actually reduce technical uncertainty. The recipient needs time to do his/her own testing to see how the idea works (Rogers, 1983: 197). The need to test new ideas is well illustrated by the introduction of new supplier technology in Firm A (Chapter 4, Section 4.2.1)

The Sales Engineer of a supplier firm recalls the presentation that his firm made at the Supplier Day of Firm A: *Firm A was really interested in our new technology, but did not discuss any specific application with us at the time [during the Supply Day]. And we did not know that they were bidding for an order from an aircraft manufacturer. But when they won the order, they got in touch with us and said they would like to include our technology in the Programme.* The next action for the (Design) Engineers of Firm A and the (Design) Engineers and Sales Engineers of the supplier firm was to first discuss the new technology together. The discussion lasted several months and focused on the properties of the new technology, the customer's requirements, and the arising manufacturing issues. When the two parties satisfied themselves about how the new technology could be used in the customer's Programme, they joined forces to explain the benefits of the new technology to the customer.

In the foregoing example, the implementation of the new technology is an outcome of a risk taking relationship between Firm A and the supplier firm. This relationship was only in part determined by the factors of trustworthiness (ability, benevolence, integrity) of the supplier firm, or by the propensity to trust by Firm A. In fact, it could be argued that the decisive consideration to implement the new supplier technology was a result of good social relationships between the (Design) Engineers of Firm A and the (Design) Engineers and the Sales Engineers of the supplier firm. The social relationships entailed trust, access to new knowledge, and learning, and resulted in creating an environment of competence and benevolence conducive to the implementation of the shared knowledge. Therefore, Firm A and the supplier firm can be said to have a trusted weak tie relationship with one another.

Similarly, in Firm B, the implementation of new technology, proposed by a supplier firm, may also be interpreted as an outcome of a trusted weak tie relationship. The suggestion came from a supplier firm that was familiar with the technical functions of the Firm B's products: *You are always looking for materials with optimal stiffness, or a low friction coefficient, don't you? I have just seen a new material combination; wouldn't that be something for you?'* (Chapter 5, Section 5.2.1). Thus, the ultimate implementation of the new technology by Firm B was not a result of any specific information search, or information processing, but a result of a social relationship arising from (identification-based) trust (Lewicki and Bunker, 1996) between the supplier firm and Firm B. The social relationship bears the characteristics of a trusted weak tie relationship because it promotes both learning and access to novel information.

BOX 8.4

REFLECTIVE COMMENT on the Multicase Theme of TRUST based on the Integrative Model of Dyadic Trust in Figure 8.2.

The case evidence points towards the important role of trust in the information relationships in the FFE of NPD. The Integrative Model of Dyadic Trust (Mayer et al., 1995) is helpful in explaining the dyadic information relationships because it:

- describes the information relationships as a risk taking activity;
- underlines the vulnerability of the exchange parties; and
- shows the evolving character of information relationships (the feedback loop).

However, in order to be fully applicable to the dyadic information relationships, the Model needs to differentiate between the two phases in the outcome of a risky information relationship: the adoption and the implementation of information and knowledge.

The term adoption implies 'being aware of', and leaves open the option to turn down (i.e., not to implement) the received information and knowledge. Furthermore, the Model describes the trustworthiness factor of benevolence as a characteristic of the trustee only. The case evidence shows that the environment of benevolence involves the trustor as well as the trustee. In consequence, benevolence should be understood as a two-way relationship. A suggestion to incorporate the concept of trusted weak ties into the Model will be made in Chapter 9.

8.4 *Stage Three:* The validation of Research Questions through Salient Issues and Multicase Themes

The 22 Salient Issues (Table 8.1) that have been identified in the dyadic information relationships between the functions of (Design) Engineering, Purchasing, and Sales Engineering in customer and supplier firms, originate from the second round of data analysis, which took the form of Within-case Analyses of the four focal firms (Chapters 4-7).

The Within-cases Analyses were based on the verbatim transcripts of interviews and meetings, and were guided by the What's, the How's, and the Why/Why not's of the Research Questions. The identified Salient Issues were subject to further analysis (Section 8.2) which resulted in the identification of four Multicase Themes, namely: Social Ties, Single Sourcing, Physical (Boundary) Objects, and Trust. The manifestations of the Multicase Themes in the four focal firms were analysed against the background of scholarly literature in order to establish the Multicase Themes' credibility (Section 8.3).

In Table 8.9, the process of the data analysis is reversed: the researcher aligns the Salient Issues and the Multicase Themes with the Research Questions in order to get an overview of the relatedness of the Research Questions to the four case reports, and thereby validate the Research Questions.

The validation of the Research Questions consists of checking whether the Research Questions are evenly distributed over the four cases, and whether the subject matter of the Salient Issues and the Multicase Themes relate to the subject matter of the Research Questions. In other words, whether the focus of the four case studies is aligned with what the Research Questions had set out to investigate. Table 8.10 shows how the distribution of the Research Questions over the four firms relates to the number of case study informants, and the length of case reports.

Table 8.9 Validation of Research Questions

Research Questions (RQ)	Which Salient Issues (SI) relate to which RQ?	From which Firm?	Which Multicase Theme relates to which SI and RQ?
RQ 1: What does constitute an information relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of supplier and customer firms during the fuzzy front end (FFE) of new product development (NPD)? What type of information and knowledge is exchanged?	**SI 3:** Sole Sourcing and information and knowledge exchange. **SI 8:** Single Sourcing and information and knowledge exchange. **SI 11:** Physical Objects are information bearers in the conceptual design stage. **SI 19:** Physical products, such as prototypes, are information bearers during the design process. **SI 20:** Single Sourcing and information and knowledge exchange.	**A** **A** **B** **C** **D**	**PHYSICAL (BOUNDARY) OBJECTS** **SINGLE SOURCING (by necessity) E.g., proprietary parts**
RQ 2: How does an information relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of supplier firms and customer firms work? How does the exchange of information and knowledge take place?	**SI 1:** Information and knowledge exchange through social ties. **SI 6:** The exchange of information and knowledge as business courtship. **SI 7**: The supplier's Sales Engineer as a social mediator between his/her firm and the customer's (Design) Engineers. **SI 10:** Preferred suppliers as a source of information and knowledge. **SI 13:** The role of Single Sourcing and Preferred Suppliers in the context of information and knowledge exchange. **SI 14:** Audits and Supplier Development as mechanisms for the exchange of information and knowledge. **SI 17:** Organizational forms of information and knowledge exchange. **SI 21:** Relational properties of the information and knowledge exchange.	**A** **A** **A** **A** **B** **B** **C** **D**	**SOCIAL TIES** **SINGLE SOURCING (by choice)**
RQ 3: Why do some information relationships between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineers of supplier and customer firms lead to the utilization of supplier information and knowledge, and other do not?	**SI 2:** Knowledge properties of social ties **SI 4:** The role of trust in information and knowledge exchange. **SI 5:**The strength of social ties **SI 9:** The negotiating value of information and knowledge. **SI 12:** The strength of social ties' role in the valuation of information and knowledge exchange. **SI 15:** Engineering educational background of Purchasing staff. **SI 16:** The relational assets of Single Sourcing. **SI 18:** Prioritising relationships in the information and knowledge exchange **SI 22:** The role of social ties in troubleshooting events between customer and supplier firms	**A** **A** **A** **A** **B** **B** **B** **C** **D**	**TRUST** **SOCIAL TIES**

Table 8.10: Research Questions occurrence related to the number of participants and case report length (e.g., Firm A, RQ1=2x means that two Salient Issues identified in Firm A are related to RQ1)

Firms	Research Questions (RQ) occurrence as stated in Table 8.10	Number of case study informants	Case report page length
A	RQ1 = 2x; RQ2 = 4x; RQ3 = 4x	15	24 (pages)
B	RQ1 = 1x; RQ2 = 2x; RQ3 = 3x	9	20
C	RQ1 = 1x; RQ2 = 1x; RQ3 = 1x	9	23
D	RQ1 = 1x; RQ2 = 1x; RQ3 = 1x	6	13

8.5 *Stage Four:* Cross-case Assertions about the Multicase Themes in relation to the Conceptual Framework

Stake (2006) defines Assertions as the researcher's findings about the phenomenon under study. Assertions are based on evidence, and the evidence must accompany each Assertion so that the reader is given opportunity to learn the reasons behind the Assertions. Assertions must be persuasive and credible. Cross-Case Assertions are based on commonalities and differences found in the single context bound case reports. "Evidence in multicase studies will not win over every critic, but it does need to be persuasive to critical friends." (Stake, 2006: 41). The hierarchy of researcher's assertions was presented earlier in Chapter 3, Table 3.2 when describing the thesis' analysis strategy.

Figure 8.3 illustrates the Chain of Evidence (Yin, 2003), with the steps in analysis that preceded and follow the formulation of the Cross-case Assertions about the Multicase Themes. The Chain of Evidence started with the Within-case analyses of the four firms (Chapters 4-7), resulting in the identification of 22 Salient Issues in the dyadic information relationships in relation to the utilization of supplier information and knowledge in the FFE of NPD. Next, the Salient Issues were examined for the presence or absence of cross-cutting themes. Four Multicase Themes were identified. This was followed by an analysis of the Multicase Themes against the background of primary scholarly works so as to ascertain the credibility of the Multicase Themes.

The Cross-case Assertions about the Multicase Themes (the subject of the present chapter) are reached by placing the Multicase Themes in the context of the Conceptual Framework (Figure 3.3 in Chapter 3). The constructs of the Conceptual Framework are used in order to assess the fit between the evidence captured in the Multicase Themes and the Conceptual Framework. Lastly, the Cross-case Assertions provide a new lens with which to review the Conceptual Framework (Section 8.6).

The next paragraphs will formulate the Cross-case Assertions about the Multicase Themes of Social Ties, Single Sourcing, Physical (Boundary) Objects, and Trust with the help of the three constructs of the Conceptual Framework, namely:

- dyadic information relationships;
- tie modality; and
- utilization of supplier information and knowledge.

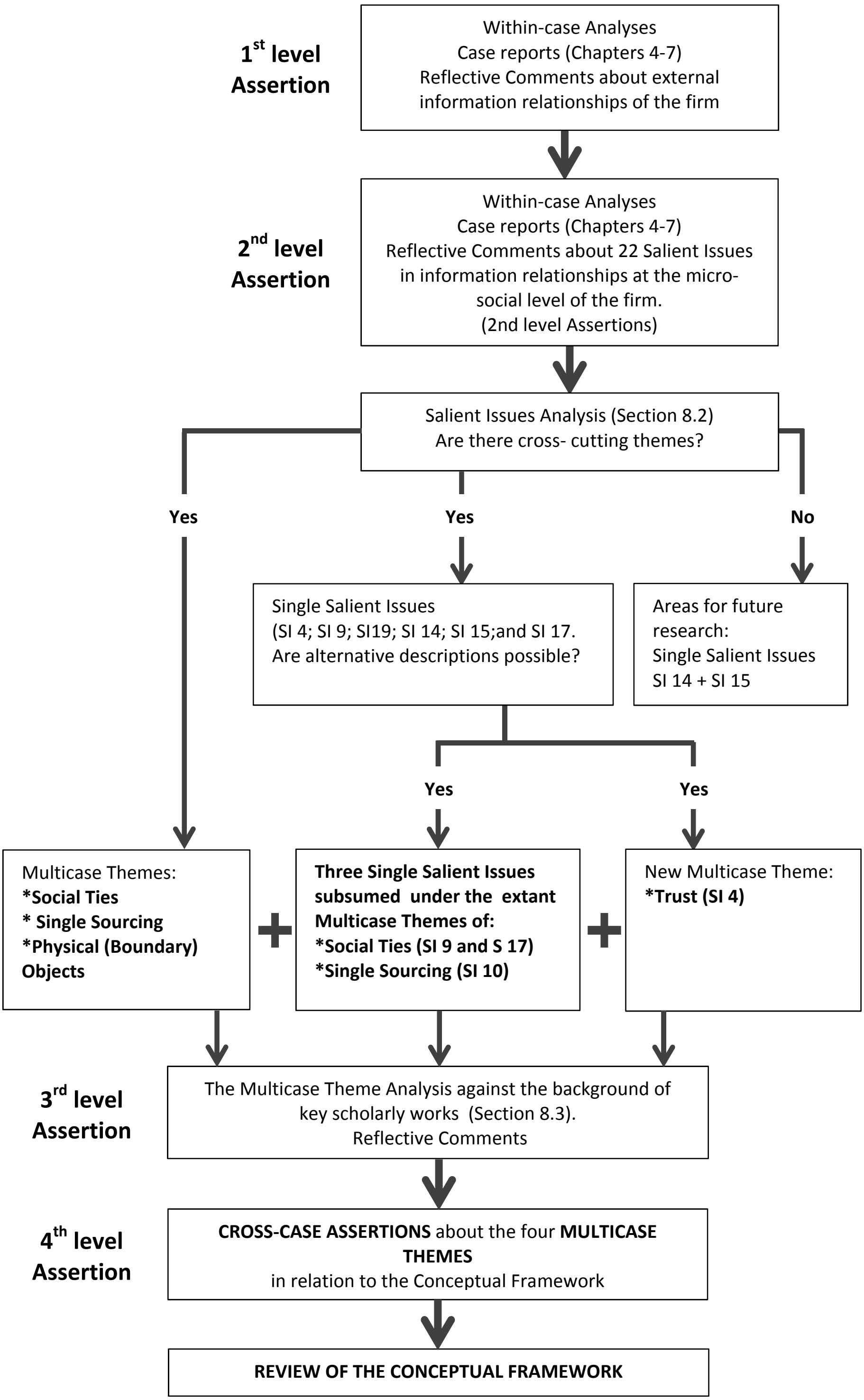

Figure 8.3 Chain of Evidence: steps in the analysis.

The Cross-case Assertions about the Multicase Themes are presented in the following order:

- Social Ties (Section 8.5.1);
- Single Sourcing (Section 8.5.2);
- Physical (Boundary) Objects (Section 8.5.3); and
- Trust (Section 8.5.4).

8.5.1 Cross-case Assertion about Social Ties

The concept of social ties as conduits for knowledge transfer dates back to Granovetter (1973, 1982) and Uzzi (1996, 1997). Subsequent research that specifically focused on knowledge transfer in NPD found that knowledge in NPD is often 'sticky'; i.e., difficult to transfer (Von Hippel, 1994), but that 'sticky knowledge' can be transferred through social ties (Hansen, 1999; Szulanski, 2002). Szulanski (2002) even suggests that one can partially predict stickiness by analysing the quality of social ties between the information provider and the information recipient.

The Conceptual Framework in Figure 3.3 (Chapter 3) offers a choice of three types of social ties, namely: strong, ties, trusted weak ties, and weak ties. Of the three types, the trusted weak tie can be viewed as a hybrid tie because it combines the positive properties of weak ties (i.e., provides access to novel and diverse information) and the positive properties of strong ties (i.e., enables learning, trust in the competence of knowledge source, and reciprocal assistance in solving problems).

The next paragraphs place the case evidence about the Social Ties in the context of the Conceptual Framework, using the Framework's constructs.

Dyadic information relationships

How do social ties function in the dyadic information relationships in the four focal firms?

Here it is necessary to state at the outset that although the case study informants were not familiar with the concept of social ties as conduits for knowledge transfer, they instantly recognized it, when the concept was explained. This fact notwithstanding, the informants found it difficult to explain their own information relationships with colleagues and/or supplier's Sales Engineers in those terms. Consequently, the interview transcripts contain only general references to social ties.

For example, the Purchaser in Firm D observes: *The strong ties require hard work. It takes sometimes 5-6 years to create a solid team, it is a group process. […]. The ties are informal and diverge from the official organization structure. One knows whom to contact.* (Chapter 7, Section 7.2.) And the (Design) Engineer working in the same firm (Firm D) concurs: *Personally, I think that the functioning of an organization is based on relationships rather than on a formal structure. You seek advice from someone who you know. You don't stop to think that there could be official channels for contacting people* (Chapter 7, Section 7.2.2).

The (Design) Engineer in Firm B indirectly refers to the existence of social ties when he says: *The communication lines in our firm are short. It is not that one department wouldn't know what the other is doing. That's what makes the information exchange (because that's what's all about) very easy. Everyone has his own ideas, his own contacts and news over a certain area of work. Every two weeks we have a departmental meeting where such issues can be raised* (Chapter 5, Section 5.2.1).

The Chief Engineer in Firm A suggests that: *Generally, the people on the list (research questionnaire) are trusted weak ties at the moment […]. The people from […] department up until recently were also a trusted weak tie, but it's a strong tie now, because I have arranged regular sessions with them. […]. Suppliers are trusted weak ties.*(Chapter 4, Section 4.2.1).

In Firm C, the Sales Engineer laughingly points out that his work may have repercussions for his social life. *When I help a customer, he is happy with my work and he buys my product. When he is not happy because I am trying to sell him something that he neither wants nor needs, then I am out of business. I also live in this area, and it's not a large area, and so I also meet customers socially. So if they are not happy with my work, they won't say 'hello', but punch me instead…* (Chapter 6, Section 6.2.2)

Thus, although the case informants did not specifically relate the function of social ties to their work, the Within-case Analyses (Chapters 4-7), and the subsequent analysis of the Salient Issues (Section 8.2) nevertheless produced evidence of the implicit presence of social ties in the informants' information relationships, with the result that Social Ties emerged as a Multicase Theme (Section 8.3.1).

Tie modality

Which of the three types of social ties (strong, weak, and trusted weak) can be said to predominate?

The external social ties of the four focal firms with supplier and customer firms cannot be described as a weak tie relationship because the supplier firms in the present study all enjoy the status of a preferred supplier. This means that the firms have trust in each other's competence. However, that trust is not unconditional as it would be in the case of a strong tie relationship. The status of preferred supplier can be repealed when the performance of the supplier firm is not satisfactory.

The analysis of Social ties as a Multicase Theme in Section 8.3.1 and the Reflective Comment (Box 8.1) have already alluded to the role that trust plays in determining the strength of social ties. Looking at the case evidence (e.g., the hand tool development in Firm A; the development of steel housing/casing in Firm B; the pilot projects on the Gripper component in Firm C; and the upgrade of air driers in Firm D), it may be concluded that the information relationship between the firms and their preferred suppliers answers to the definition of a trusted weak tie relationship because it combines access to novel knowledge with learning, and ultimately, the utilization of the accessed knowledge.

The internal social ties in the four focal firms oscillate between strong ties and trusted weak ties, with strong tie relationships being more an exception rather than the rule. Strong ties are mostly in evidence in project teams (e.g., the diverse Programme teams in Firms A and D), although the transitory character of project teams (once the project is completed, the team members move on to other projects) gives the team's social relationships more an appearance of an ad hoc team which is based on swift trust (Mayerson et al., 1996; Robert Jr. et al 2009), rather than on the unconditional trust of strong ties.

Moreover, the function of internal social ties as conduits for the exchange of information may vary from situation to situation. The exchange of information within a team can be quite different from the information exchanges between the teams, and across the organization, as observed by the supplier's Sales Engineer when he commented on a haphazard way the product information was passed around in Firm A: *I can tell one account team about a new product but I can never be sure that the information will be passed on to another team.* (Chapter 4, Section 4.2.1). Similarly, the HQ of Firm C did not find it necessary to share the test findings from the diverse national pilot projects with the firm's Subsidiaries. The inconsistency and fluctuation in the exchange of information can be seen as an indication that whether or not information and knowledge are disseminated is subject to changes in trust and the wish to learn on the part of the exchange partners. Trust and learning characterize a trusted weak tie relationship.

Utilization of supplier information and knowledge

The case evidence suggests that the perception of how the strength of ties influences the utilization of knowledge involves both benevolence and learning. For example, a Senior (Design) Engineer in Firm A notes that: *Some people can explain things very well; but others can actually demonstrate how to tackle a particular problem* (Chapter 4, Section 4.2.1). In other words, people can provide novel information, but when they take time to demonstrate the information they also show benevolence towards the information recipient. They care about whether or not the information has been understood. The above comment makes clear that the recipient appreciates the implicit trust and learning that such a (trusted weak tie) relationship brings.

Drawing on the case evidence, a Cross-case Assertion about Social Ties reads as follows:

> **In the context of the Conceptual Framework, the trusted weak ties represent a mechanism through which the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineers of customer and supplier firms can both access and utilize supplier information and knowledge.**

8.5.2 Single Sourcing

The analysis of the Multicase Theme of Single Sourcing and its manifestations across the four focal firms, performed in Section 8.3.2 signalled the existence of two variants of the Single Sourcing strategy: the strategy of 'Single Sourcing by necessity' (evidenced in Firm A and D), and the strategy of 'Single Sourcing by choice' (evidenced in Firms A, B, C, and D). The Reflective Comment (Box 8.2) highlighted the knowledge-related benefits of Single Sourcing.

The next paragraphs discuss the case evidence further by placing the strategy of 'Single Sourcing by necessity' and the strategy of 'Single Sourcing by choice' in the context of the Conceptual Framework, using the Framework's constructs.

Single Sourcing by necessity (evidenced in Firms A and D)

In Firm A, the necessity to adopt the strategy of Single Sourcing arises either from the customer's wish to use only proprietary parts in the built-to-print orders or from the need of Firm A to ensure compatibility of product parts that come from different suppliers. In Firm D, the necessity for Single Sourcing is given by the fact that the customer firms accept only product parts that comply with the military specifications.

Dyadic information relationships

When the firm adopts the strategy of Single Sourcing by necessity, the utilization of the product parts that the customer firm had prescribed, can be taken for granted. Therefore, it could be assumed that there would be neither need, nor occasion for the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering to engage in any information relationship, and consequently, for the activation of social ties. The case evidence shows that such assumption would be incorrect. In fact, the (Design) Engineers, Purchasers and Sales Engineers on both the customer and supplier side are continually involved in looking for cheaper alternatives to the prescribed product parts, such as COTS (commercial off-the-shelf) alternatives.

In Firm A, the exchange of information and knowledge takes place within the Affordability initiatives. The Programme Director of Firm A describes this joint effort as follows: *Based on our knowledge of the supplier market, we can suggest to our customers which proprietary parts in their design could be substituted with COTS parts, and which suppliers to choose for the development of the substitute parts. Once the customer agrees, our Purchasing department contacts the relevant suppliers. And what you see is that the suppliers are frequently prepared to cooperate and invest in developing an alternative to proprietary parts.* (Chapter 4, Section 4.2.) The Sales Engineer of one of the participating suppliers concurs: *Participating in the Affordability initiatives raises our profile as an innovative firm* (Chapter 4, Section 4.2.2).

In Firm D, the joint initiative of the Commodity Team of Firm D and the (Design) Engineer and Sales Manager of the supplier firm to replace the expensive compressors in air driers by a COTS alternative was not successful. In the words of the supplier's Account Manager: *There was a perception on the part of the customer, and also on the part of some (Design) Engineers in Firm D, that had the air drier been equipped with* *compressors containing a military specification motor, and not with COTS compressors, the air drier would not have broken down.* (Chapter 7, Section 7.2.3)

In summary, the dyadic information relationships during the strategy of Single Sourcing by necessity are motivated by concerns about cost reductions.

Tie modality

How does tie modality affect the information relationships in cases of Single Sourcing by necessity?

In the present thesis, the supplier firms of the four focal firms are all so-called 'preferred suppliers', that is, the supplier firms have been screened and approved by the Purchasing department according to the product quality and production performance criteria. This fact rules out the existence of a weak tie relationship.

A strong tie relationship is also not probable. Although preferred suppliers enjoy a certain level of trust, this trust is not automatic, and it is not taken for granted, as is the norm in a strong tie relationship. On the contrary, preferred suppliers are subject to continual evaluation of their performance by the customer firms.

At the same time, any proposal to replace the customer's product parts by cheaper alternatives involves elements of risks. Therefore, such decisions need to be taken in an environment of benevolence and competence based trust, that is, in the environment in which the dyadic partners are connected through trusted weak ties.

Utilization of supplier information and knowledge

In the strategy of Single Sourcing by necessity, the utilization of the prescribed product parts is a natural consequence of the customer's requirements, based on trust in the customer's judgment and can therefore be designated as a trusted weak tie relationship.

Single Sourcing by choice (evidenced in Firms A, B, C, and D)

The strategy of 'Single Sourcing by choice' is practiced in all four focal firms. Seeking out supplier information and knowledge through Single Sourcing is motivated by a wish to increase or maintain the firm's competitive advantage.

Dyadic information relationships

Perhaps the most unexpected occurrence of Single Sourcing by choice was found in Firm A. The occurrence was unexpected because the Purchasing department of Firm A pursues a policy of Single Sourcing avoidance. Not surprisingly, therefore, the few instances of Single Sourcing by choice that Firm A introduced, had all been launched at the initiative of the (Design) Engineers.

The initiatives concerned internal projects, and had as objective to keep ahead of the competition by improving the firm's production facilities (e.g., the development of hand tool; the development of tooling machine), or to anticipate future technology developments (e.g., 'Sounding board'). These internal projects typically involved long-term information relationships between the (Design) Engineers of Firm A and the

Sales Engineers and (Design) Engineers of the supplier firms. The utilization of supplier information and knowledge was not subject to any time constraints.

The instances of Single Sourcing by choice involving external projects, concerned product development aiming at achieving specific benefits for customer firms (e.g., qualifying a new product part in Firm A, the steel housing/casing in Firm B, the Gripper component in Firm C, and the air drier upgrade in

Firm D). The Sales Engineer in the Regional Subsidiary of Firm C sketches the type of benefits sought: *We sell knowledge by trying to find the right solution for the customer. The problem solving aspect of our work is important when using intelligent products, and when the inside of the products is complex. Our product can be applied in a number of different ways, and the customer turns to us for advice.* (Chapter 6, Section 6.2.2). In Firm D, the Commodity Team leader justifies the strategy of Single Sourcing by choice by emphasizing the supplier's knowledge: *In this particular case, we wanted to have the benefit of the expertise of this particular supplier. The supplier firm also delivers compressors to the civil market, and has therefore a good overview of technologies available.* (Chapter 7, Section 7.2.3)

In summary, the dyadic information relationships during the strategy of 'Single Sourcing by choice' are motivated by an opportunity to share knowledge and finding common solutions.

Tie modality

How does tie modality affect the information relationships when the firm adopts the strategy of Single Sourcing by choice?

Similarly, as in the case of Single Sourcing by necessity, a weak tie relationship in the case of Single Sourcing by choice can be ruled out because of the preferred status of the supplier firms involved. Neither can the information relationships that accompany Single Sourcing by choice be regarded as a strong tie relationship. It is true, that the exchange of information is intensive, but unlike in strong tie relationships, the issues of trust and competence are constantly under review. The supplier's Sales Engineer, participating in the Integrated Product Team of Firm A notes the exclusivity of trust: *They [Firm A] are under so much pressure to get a qualified part in time before the production begins, so they need to work with just one preferred supplier only. And, luckily, that's us. […] Firm A has a problem and found in us a partner who can help solve the problem. And they trust us.* (Chapter 4, Section 4.2.1). The (Design) Engineer in Firm B explains what he expects from an information relationship with a preferred supplier: *[…] if the supplier is not able to provide the information I need, then he is of no use to me* (Chapter 5, Section 5.2.2).

The only social tie relationship that embodies and unites the properties of learning, trust, and access to novel information and knowledge is a relationship of trusted weak ties. Therefore, it may be assumed that the information relationships between the parties involved in the strategy of Single Sourcing by choice is formed through trusted weak ties.

Utilization of supplier information and knowledge

In the strategy of Single Sourcing by choice, the utilization of supplier information and knowledge in the FFE of NPD is conditioned by a belief that supplier firms have knowledge to contribute and that problems in NPD can be solved jointly with the supplier.

Drawing on the case evidence, a Cross-case Assertion about Single Sourcing reads as follows:

> **In the context of the Conceptual Framework, the strategy of Single Sourcing represents a form of dyadic information relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering of customer and supplier firms. Single Sourcing leads to the utilization of supplier information and knowledge on condition that the dyadic information relationship between the provider and recipient is based on benevolence and competence based trust as embodied in the trusted weak ties between the dyadic partners.**

8.5.3 Cross-case Assertion about Physical (Boundary) Objects

The analysis of the Multicase Theme of Physical (Boundary) Objects in Section 8.3.3 (summarized in Table 8.7) illustrated the wide range of the Physical (Boundary) Objects that were in use in the four firms.

The analysis focused on three functions of Physical (Boundary) Objects, as defined by Carlile (2002), namely, the functions of representing, learning and transforming.

To these three functions, the present thesis has added one more function, namely, that of evidencing, placed in the last column in Table 8.7. The function of evidencing reveals how the Physical (Boundary) Objects impact (are evidenced in) the information relationships of their users.

The Reflective Comment (Box 8.3) described the evidencing function of the Physical (Boundary) Objects as producing goodwill and trust towards and on behalf of the objects' users. The evidencing function of Physical (Boundary) objects can be summed up by the words: *'seeing is believing'*.

The next paragraphs discuss the Physical (Boundary) Objects in the context of the Conceptual Framework, using the Framework's constructs.

Dyadic information relationships

The use of Physical (Boundary) Objects is commonplace in all four focal firms. The dyad of Purchasers and (Design) Engineers works with the Physical (Boundary) Objects, such as Risk Mitigation Plans in Firm A, or the AHP surveys in Firm B. The Physical (Boundary) Objects facilitate communication between these two functions by making each other's standpoints explicit.

In the dyad of R&D Engineers and the supplier's Sales Engineers, the Physical (Boundary) Objects, such as prototypes, help clarify the proposed design solutions. In Firm C, the prototypes of the Gripper component are deployed to solicit views from customer firms with regard to product specifications.

In summary, the Physical (Boundary) Objects form an essential part in the way the dyadic information relationships function: the Physical (Boundary) Objects help initiate a dialogue between their users.

Tie modality

How does tie modality affect the use of Physical (Boundary) Objects?
The Reflective Comment (Box 8.3) referred to the property of Physical (Boundary) Objects to make tacit knowledge communicable to others. To be successful, however, such communication must be a two-way process. The tacit knowledge contained in the Physical (Boundary) Objects must find a willing recipient.

In a strong tie relationship the reciprocal communication of information and knowledge is taken for granted, and trust in the competence of the knowledge source is a given. One would expect that individuals from the same functional area and working in the same firm would have a strong tie relationship with one another. The case evidence, however, suggests that trust in the competence of a fellow professional is not given lightly.

For example, the Senior R&D Engineer in Firm B stresses the need to convince both the customer firms as well as his colleagues in Product Development (PD) about the benefits of a new product concept: *Starting with a second product sketch, PD (Product Development) Engineers are already looking over our shoulder. They need to feel confident that the product can be mass produced. You have to convince them as well as the customer* (Chapter 5, Section 5.1.1). Here, the sketches, act as proxies for trust which would normally be a standard feature in a strong tie relationship.

The Physical (Boundary) Objects, such as prototypes and product samples can also be used as a means to access new knowledge. For example, when supplier firms are asked to make product prototypes, they provide a proof of the product's manufacturability. Thus, it could be argued, that the ability of the Physical (Boundary) Objects to make new knowledge accessible, makes the Physical (Boundary) Objects an ideal starting point for a weak tie relationship. However, the case evidence also shows that even more important than accessing new knowledge is the environment of trust and goodwill in which such exchange of information takes place. The Reflective Comment (Box 4.9) in Chapter 4 used the term 'courting' (Lewicki and Bunker, 1996) to describe the exchange of fully functional product samples between Firm A and its preferred suppliers.

In summary, the Physical (Boundary) Objects help access new knowledge but also contribute to the building of trust and goodwill in an information relationship. Therefore, tie modality of the information relationship involving the deployment of the Physical (Boundary) Objects can be designated as a trusted weak tie.

Utilization of supplier information and knowledge

Does the use of Physical (Boundary) Objects lead to the utilization of supplier information and knowledge?

The case evidence gives a negative answer. Instead, the case evidence suggests that the Physical (Boundary) Objects serve as a stepping stone to the utilization of supplier information and knowledge.

For example, in all focal firms the testing of product prototypes influences whether or not the firm proceeds with further development of the product. Similarly, the use of drawings in Firm B shows the mediating role of drawings in the tolerances debate. The Quality Control Engineer of Firm B notes: *We distinguish between the dimensional validity of parts which are periodically checked and verified through the PPAP (Production Part Approval Process) procedure, and the 'special characteristics' of product parts which are defined in the technical drawings of PD Engineers. I need to know how realistic are the tolerances that are set in the drawings, and even more importantly: can the tolerances be measured? What you often see is that in drawings the tolerances are very tight, whereas in production you want to have larger tolerances [...]* (Chapter 5, Section 5.2.1).

The literature (Rogers, 1983, Van Aken, 2005) describes the utilization of knowledge in innovation and design as a process consisting of two phases: adoption and implementation. The case evidence presents a similar picture. The use of the Physical (Boundary) Objects represents the adoption phase of the utilization, and paves the way to the implementation of supplier information and knowledge in the FFE of NPD.

Drawing on the case evidence, a Cross-case Assertion about Physical (Boundary) Objects reads as follows:

> **In the context of the Conceptual Framework, Physical (Boundary) Objects represent a stepping stone to forming a trusted weak tie relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering of customer and supplier firms, and represent the adoption phase in the utilization of supplier information and knowledge.**

8.5.4 Cross-case Assertion about Trust

The Reflective Comment on Social Ties (Box 8.1) and the Reflective Comment on Trust (Box 8.4) have already referred to the overlap between trust and social ties in the dyadic information relationships involving individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering of customer and supplier firms. The case evidence suggests that trust and social ties feed off each other, thus creating learning opportunities for the dyad partners. The next paragraphs discuss the case evidence further by placing Trust in the context of the Conceptual Framework, using the Framework's constructs.

Dyadic information relationships

Accepting the expertise of another party takes time and trust. The Programme Manager in Firm A notes: The customers say to us: "You are the Specialists", but they outsource [to us] only part of their manufacturing, and keep a backup manufacturing plant of their own. It is only when the customers feel they can put their trust in Firm A that they start closing down their manufacturing plants (Chapter 4, Section 4.1.1). Thus, acknowledging supplier knowledge (i.e., being aware of it) does not automatically lead to the utilization of that knowledge by fully implementing it.

Tie modality

Trust and social ties feed off each other, but the effects need not always be positive. The Commodity Team Leader in Firm D is aware of such risk: *Of course, the Commodity Team can acquire this image of a strong referee or a high priest, someone who tells people how the purchasing works. However, in practice it is different. You have to make allowances, give room to Programme (Design) Engineers to ask the supplier firm:"How much would it cost if we were to do it this way?" And afterwards, the (Design) Engineers come to us and we formalize the agreements with supplier firms together. You have to show some flexibility otherwise you cannot operate as a company* (Chapter 7, Section 7.2.2). The case evidence suggests that in order to achieve flexibility in the information relationship between Purchasers and (Design) Engineers mutual trust is essential.

Utilization of supplier information and knowledge

The overlap between trust and social ties in the information relationships is also reflected in the utilization of supplier information and knowledge. The Purchasing Product Manager in Firm D remarks: *You don't have to have all knowledge in-house, because there is a wealth of knowledge on the market. That means that sometime you must take money to the supplier in order to get his knowledge, whereas in former times (when Firm D was a vertically integrated company) that kind of information was so-called free.* (Chapter 7, Section 7.1). Unstated, but implied in this remark is, that Firm D actually knows to which supplier firms to turn for advice, and that Firm D also trusts these firms.

In the pilot project of the Gripper component in Firm C, the Director of a customer firm joined the pilot project because he was confident of the competence of Firm C with which he had positive experience in the past. When the Gripper component failed the pick-and-place cycle tests, the Director sums up his loss of trust as follows: *If the Gripper component would help my customer through the season then I would regain my trust in the product. At the moment, I don't have that trust but am prepared to be convinced of the opposite. (Chapter 6, Section 6.3).* In other words, the failure of the Gripper component did not afflict the Director's trust in Firm C as a whole, but the utilization of the Gripper component was put on hold.

Drawing on the case evidence, a Cross-case Assertion about Trust reads as follows:

In the context of the Conceptual Framework, trust between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering of customer and supplier firms is vital, but once-only trust is not sufficient for the utilization of supplier information and knowledge to take place. Trust needs to be embedded in social relationships based on benevolence and competence between the dyad partners.

In summary, the Cross-case Assertions represent the last-but-one step in meeting the objective of the Cross-case Analysis which was to arrive from single cases to universality. The Cross-case Assertions offer a new lens through which to assess the universality of the Conceptual Framework. There still remains the question of how well the Conceptual Framework explains the utilization of supplier information and knowledge in the FFE of NPD across the four focal firms.

The Cross-case Assertion about the Multicase Theme of Physical (Boundary) Objects, and earlier, the analysis of the Multicase Theme of Trust (Section 8.3.4, Box 8.4) have brought to light that the utilization of supplier information of knowledge should be viewed as a two phase process consisting of the phase of adoption and the phase of implementation. The following review of the Conceptual Framework will take these insights into account.

8.6 *Stage Five:* Review of the Conceptual Framework in the light of Cross-case Assertions

The objective of Stage Five, the last part of the Cross-case Analysis, is to review the Conceptual Framework (Figure 3.3 in Chapter 3) in the light of the Cross-case Assertions, and the case evidence in general. The outcome of the review is presented in in the final Conceptual Framework in Figure 8.4. The next paragraphs review the Framework's three constructs in turn.

The construct of dyadic information relationships

The Framework in Figure 3.3 presents the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering as the chief 'movers' behind the exchange of information and knowledge in the FFE of NPD. Their information relationships are depicted as dyadic interactions. The findings of the present thesis support this supposition.

The case evidence suggests that firms prefer dyadic information relationships over group relationships. The reasons are mostly pragmatic. In the example of 'Sounding board' in Firm A, the Senior (Design) Engineer explains the advantages of approaching the supplier firms individually (i.e., through a dyadic relationship), rather than approaching the suppliers as a group: *To bring suppliers together makes no sense because it would only result in one joint design. Dealing with each supplier separately means that each supplier comes with their best ideas.*(Chapter 4, Section 4.2.1).

The preference for dyadic information relationships is also apparent in the decisions firms make with respect to the choice of a sourcing strategy. The case evidence (Section 8.2.1), shows that all four firms adopt the strategy of Single Sourcing by choice (i.e., a dyadic information relationship) whenever they want to derive most benefit from the utilization of supplier information and knowledge.

The information relationships in the Conceptual Framework (Figure 3.3 in Chapter 3) are shown as diverse intra-and inter-firm dyad configurations of three functional areas of the customer and supplier firm. This diversity in dyad configurations allowed to investigate the utilization of supplier information and knowledge from the perspectives of both the users and the providers, and resulted in the identification of a mechanism that caused the utilization of supplier information and knowledge to take place. The case evidence (Section 8.3.1) suggests that the underlying mechanisms for the utilization of supplier information and knowledge in the FFE of NPD are social ties.

Having helped to identify the causal mechanisms, the specific configurations of the dyadic information relationship become less important. Therefore, the Conceptual Framework in Figure 8.4 no longer enumerates the diverse configurations but instead stresses the dyadic character of the information relationships between the functional areas at the micro-social level of the firm.

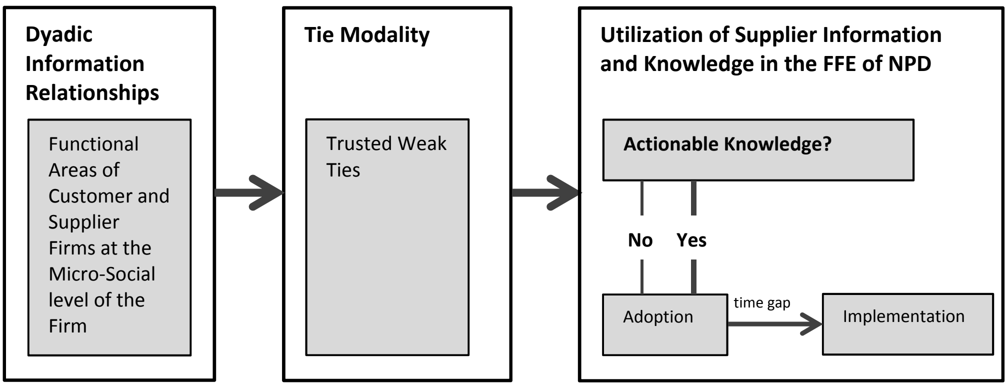

Figure 8.4: Final Conceptual Framework

The construct of tie modality

The Conceptual Framework in Figure 3.3 presents three types of social tie: weak ties, strong ties, and trusted weak ties.

The present thesis found, that in the given context of the four focal firms, a weak tie relationship was rare. At the firm level, the temporal character of weak ties runs counter the firms' goal to achieve stability and reciprocity in their business relationships.

The status of 'preferred supplier', with which the firms award the supplier firms that have been screened and vetted by the firm's Purchasing department, attests to the firms' preference for long term relationships.

At the micro-social level, Internet searches by individuals could be classified as weak tie relationships because such searches provide access to novel information with no requirements of reciprocity. In the Case Vignette of tooling machine (Section 4.1.2) in Firm A, a Project Engineer found on the Internet an engineering bureau that, according to its website, had the capabilities to develop a tooling machine. However, a decisive factor in the hiring of the engineering bureau was the fact that the bureau had done projects in the past for a sister organization of Firm A. Consequently, the Project Engineer could turn to a trusted source for additional information. In fact, the weak tie relationship (a search on the Internet) was quickly submerged into an extant trusted weak tie relationship.

In Firm B the Head of Product Development noted that Internet searches were not always a solution: *Actually it was quite surprising to see that, even with the Internet which makes a world-wide search easy, there were only very few firms that could do this kind of work* (Chapter 5, Section 5.2.1). In the end a supplier firm was found through a face-to-face meeting with the Director of a supplier firm at a trade show. The supplier firm did have a website but the website did not show up in the Internet search. The supplier's Director comments: *When the designer is looking for ways to produce housing/casings, he doesn't look for knowledge on deep drawn stamping. May be the designer doesn't even use our terminology. He is more interested in seeing and holding our product.* (Chapter 5, Section 5.2.3). For the (Design) Engineer, the product sample, a Physical (Boundary) Object, contained new knowledge and provided evidence about the product's manufacturability. The product sample thus marked the beginning of a trusted weak tie relationship with the supplier firm.

With regard to strong ties, the case evidence found that strong tie relationships in the focal firms were few and far between. To claim that the information relationships in project teams represented a strong tie relationship would be an overstatement. As already remarked in the analysis of the Multicase Theme of Trust (Section 8.3.4), the temporality of project teams is reminiscent of NPD ad-hoc teams in which the information relationships are based on swift trust (Mayerson et al., 1996; Robert Jr. et al 2009). Swift trust is not based on personal knowledge of the team members' past behaviour (as would be the case in a strong tie relationship), but on a swift assessment of team members' characteristics, such as gender, profession, organizational role, or a third party recommendation, etc.

Summing up: the inevitable conclusion to be drawn is that the most prevailing type of social tie between the individuals in the three functional areas under study has been the relationship of trusted weak ties. This conclusion is not a result of process by elimination but a result of the found evidence regarding the overlap between social ties and trust in the dyadic information relationships (e.g., Section 8.3.1; Box 8.1 and Section 8.3.4, Box 8.4).

Therefore, the final Conceptual Framework in Figure 8.4 limits the construct of 'Tie modality' to 'trusted weak ties' only.

The construct of the utilization of supplier information and knowledge in the FFE of NPD

The Conceptual Framework in Chapter 3 (Figure 3.3) proposed that the utilization of supplier information and knowledge was an outcome of dyadic information relationships between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of customer and supplier firms, and that this outcome would be influenced by the type of social tie. It was conjectured that the exchange of supplier information and knowledge would automatically result in the utilization of that supplier information and knowledge.

However, the case evidence drawn from the analysis of the Multicase Theme of Trust (Section 8.3.4, Box 8.4), and mirrored in the Cross-case Assertion about the Multicase Theme of 'Physical (Boundary) Objects' (Section 8.5.3) indicate that the utilization of supplier information is not an instant action, but a process consisting of two phases: adoption and implementation.

Moreover, the evidence revealed that the two phases were not temporally linked: there was no time-ordered sequence. The adoption phase in which the recipient became aware of supplier information and knowledge (i.e., the recipient either adopted or turned down the received information/knowledge) was found to be a separate process from that of implementation.

In redefining the construct of the utilization of supplier information and knowledge, the concept of *'actionable knowledge'* (Cross and Sproull, 2004), identified in the literature review (Chapter 2, Section 2.4.3), has proved useful because it combines knowledge utilization and dyadic interpersonal social relationships. Cross and Sproull (2004) defined 'actionable knowledge' as "knowledge that leads to immediate progress on a current assignment or project". In validating the concept, Cross and Sproull, 2004) found that the information relationships between the information seeker and information provider were instrumental in the way information and knowledge were used.

Translated into the context of the present thesis, and taking into account the case evidence about the dyadic information relationships and the role of trusted weak ties therein, the Conceptual Framework in Figure 8.4 makes the two-stage utilization of supplier information and knowledge conditional to the actionability of knowledge.

In conclusion, the contribution of the Conceptual Framework (Figure 8.4) to the development of theory on supplier involvement in new product development (NPD) is fourfold:

- Firstly, the Conceptual Framework concentrates on the less researched field of the FFE of NPD and the potential benefit of supplier information and knowledge therein;

- Secondly, the Conceptual Framework presents the customer/supplier interaction during the FFE of NPD as a dyadic information relationship between the functional areas at the micro-social level of the customer and supplier firm;
- Thirdly, the Conceptual Framework links the utilization of supplier information and knowledge in the FFE of NPD to the theory of Innovation Diffusion (Rogers, 1983) by highlighting the time-gap between the adoption and implementation of supplier information and knowledge; and
- Fourthly, and perhaps most importantly, the Conceptual Framework draws on the research on social ties and how social relationships facilitate and affect the exchange and utilization of information and knowledge (Cross and Sproull, 2004; Granovetter, 1973, 1982; Hansen, 1999; Levin and Cross, 2004). In consequence, the Conceptual Framework presents the utilization of supplier information and knowledge in the FFE of NPD from a relational perspective.

Future research could focus on how to measure the utilization of supplier information in the FFE of NPD. The present thesis has identified two objects of measurement (Dul and Hak, 2008), both of which are directly related to the utilization of supplier information and knowledge, and would therefore allow to extract evidence about the value of the utilization of supplier information and knowledge. The two objects of measurement are the Physical (Boundary) Objects and Single Sourcing. Thus, by measuring, for example, the frequency with which the Physical (Boundary) Objects were used in the FFE of NPD, or the frequency with which the customer firm engaged in Single Sourcing, would give an indication about the value of the utilization of supplier information and knowledge to the customer firm.

Chapter 9: **Discussion and implications**

9. Introduction

This is the last chapter of the present thesis. The foregoing chapters drew on the analysis of the raw data from the interviews with 39 individuals representing the functions of (Design) Engineering, Purchasing, and Sales Engineering about their respective information relationships in the FFE of NPD. The informants came from both customer and supplier firms. The information relationships at the micro-social level of the firm between the three functional areas formed the core of four Within-case Analyses (Chapters 4-7), and resulted in the identification of 22 Salient Issues (Table 8.1).

The following Cross case-Analysis (Chapter 8) aggregated the 22 Salient Issues into four Multicase Themes that characterized the information relationships in the FFE of NPD. The credibility of the Multicase Themes was examined by analysing the Multicase Themes against the background of primary scholarly work (Section 8.3). Furthermore, the Cross-case Analysis validated the Research Questions (Section 8.4), formulated Cross-case Assertions about the Multicase Themes (Section 8.5), and examined the Multicase Theme in relation to the Conceptual Framework (Section 8.6).

The present chapter summarizes and discusses the thesis' findings in order to answer the Research Questions. The three Research Questions are addressed in turn, each ending with remarks about the thesis' research contribution. The chapter concludes with an acknowledgement of the thesis' limitations; makes suggestions for further research, and discusses the managerial implications.

9.1 **Answers to Research Question 1**

The first Research Question addressed the What of the information relationship, as reflected in the exchange and utilization of supplier information and knowledge at the micro-social level of the firm in the FFE of NPD.

Formulated as a result of the literature research (Chapter 2), the Research Question 1 sought answers to:

> *What does constitute an information relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering of supplier and customer firms during the fuzzy front end (FFE) of new product development (NPD)? What type of information and knowledge is exchanged?*

The present thesis conceptualized the information relationship as a continuous, dynamic exchange process between the seeker/user and the provider (Borgatti and Cross, 2003; Cross and Sproull, 2004) the outcome of which is the utilization of supplier information and knowledge in the FFE of NPD. In the Conceptual Framework (Figure 3.3 in Chapter 3), the outcome of the information relationship between (Design) Engineers, Purchasing, and Sales Engineers is enabled by social ties between the seeker/user and the provider.

The discussion of the thesis' findings that help answer the Research Question 1 pertains to the following four issues:

- Dyadic and triadic information relationships;
- Single Sourcing by necessity;
- The central role of the Purchasing function; and
- The tangibility of information and knowledge of the Physical (Boundary) Objects.

Dyadic and triadic information relationships

The information relationships in the four focal firms were found to constitute dyadic interactions between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering. On the whole, dyadic information relationships were found to prevail over triadic information relationships.

This finding is interesting if only because the starting premise of the present thesis was that (Design) Engineers, Purchasers, and representatives of supplier firms would form a triadic information relationship (shown in the first version of the Conceptual Framework in Figure 3.2 in Chapter 3**)**. However, when visits to the four participating firms revealed that triadic relationships were rare, it was necessary to revise the Conceptual Framework. Here it is worth noting, that the rareness of triadic information relationship did not stem from a lack of opportunity to form such relationships but from a conscious choice of the case informants to conduct their information relationships in a dyadic mode. In this sense, therefore, the revised Conceptual Framework in Figure 3.3 in Chapter 3 represents in itself a finding of the present thesis.

The preference for dyadic relationships is, for example, apparent in the way the participating firms take decisions about the selection of product parts.

On the one hand, the dyad of Purchasers and (Design) Engineers discusses the issue of product parts in the firm's Sourcing Committee. On the other hand, the (Design) Engineers and the Purchasers hold their own separate discussions with the supplier's Sales Engineers. When such bilateral talks with the supplier firms lead to conflicting findings, the matter is put before the Sourcing Committee to be resolved by the dyad of Purchasers and (Design) Engineers. Thus, although the discussion about the choice of product parts involves three parties (i.e., a triad), the discussions are dyadic in nature.

The trust-related concerns permeate all information relationships between customer and supplier firms. In cases of manufacturing problems (e.g., tooling breakdowns in Chapter 5, Section 5.2.3), the customer firm has two alternatives. The customer firm can ask the supplier to cooperate in finding a solution to the problem (i.e., give the supplier a 'voice'), or it can look for another supplier. The joint action taken by Firm B and its supplier is a reflection of the role of trust in their information relationship in which the 'voice' approach prevailed over the 'exit' approach (Helper, 1991).

Single Sourcing by necessity

The strategy of Single Sourcing by necessity (Trevelen and Schweikert, 1988; Swink and Zsidisin, 2006) constitutes a special kind of a dyadic information relationship involving the utilization of proprietary parts recommended by the customer firm, or involving a single supplier because there is no other supplier available. What makes this dyadic information relationship special is the commitment and implicit trust between both parties that the proprietary parts are fit for the intended purpose. Thus, the exchange and the utilization of information and knowledge follow directly from one another; there is no time gap between adoption and implementation. Trust in the information relationships between the two parties is also evident when both parties are receptive to each other's proposals about cost effective alternatives (e.g., the Affordability initiatives in Firm A).

The central role of the Purchasing function

The original Conceptual Framework in Figure 3.2 in Chapter 3 envisaged a central role for the function of Purchasing in the information relationships in the FFE of NPD. The Purchasers were expected to act as boundary spanners (Castaldi et al., 2012; Reid and de Brentani, 2004, 2010), or as gate keepers (Allen, 1977) between the focal firm's (Design) Engineers and the Sales Engineers of supplier firms.

The Conceptual Framework was informed by a literature review that revealed a long line of research advocating the strategic function of Purchasing (Burt and Soukup, 1985; Ellram and Carr, 1994; Kraljic, 1983, Lakemond et al., 2001, 2006; Lamming, 1993; Schiele, 2006, 2010; Van Weele 2010; Wynstra et al., 1999, 2000, 2003).

Guided by this research, the Conceptual Framework in Figure 3.2 conjectured that the strategic role of Purchasing would be reflected in the Purchasing's involvement in NPD through the dissemination of NPD- related information and knowledge from and about supplier firms. However, contrary to expectations, the Purchasing's role in information relationships in the FFE of NPD was found to be negligible. In fact, one of the participating firms has actually reduced the status of Purchasing to that of a back office function. Clearly, the firms that took part in the present thesis perceived the function of Purchasing differently than the firms reported in the literature. There are two possible explanations for this disparity.

One explanation could lie in the way the cases in the present thesis were sampled. Unlike most of the empirical research reported in the literature, the four firms participating in the present study were not drawn from a membership database of a professional body in the field of Purchasing (of which there exist several, both nationwide and worldwide). For example, the Dutch Association of Purchasing Management (NEVI – Nederlandse Vereniging voor Inkoop Management) actively cooperates to promote research in purchasing and supply chain management. In the UK, the Chartered Institute of Purchasing & Supply (CIPS) frequently provides researchers with access to their membership database. The same cooperation is provided in Germany and Austria, by their respective Associations of Materials Management, Purchasing, and Logistics. In the US, the CAPS Research (a global research centre for strategic supply management), founded in 1986, has built a long tradition of best-practices sharing and benchmarking studies.

The consequence of case sampling with the help of professional bodies is that the selected firms are already committed to advancing the status of the Purchasing profession, and this bias is mirrored by Purchasing's involvement in NPD.

In contrast, the case sampling for the present thesis was guided by advice and recommendations from the thesis Supervisor and colleagues at work. The sampling was purposeful in the sense that the selected firms were able to provide projects with opportunities to study the interactions between the functions of (Design) Engineering, Purchasing, and Sales Engineering.

A second explanation why Purchasing did not constitute an essential element in the information relationships in the FFE of NPD could be sought in the educational background of Purchasers. The case informants voiced on several occasions their concern that Purchasers were more likely to have a business educational background rather than technical education backgrounds. The lack of engineering background of Purchasers also emerged as a Salient Issue in the present thesis (Box 5.6). The case evidence suggests that when members of Purchasing staff have an engineering education, they are in a better position to act as sparring partners for the (Design) Engineers and to assess products holistically rather than as a sum of component parts.

The case evidence indicates that, increasingly, the sparring partner for the (Design) Engineer in the FFE of NPD is not the Purchaser, as proposed in the literature, but that the role of a sparring partner is being claimed by the supplier's Sales Engineer in his/her new role as a Knowledge Worker (Darr, 2002, 2003, 2006).

The tangibility of information and knowledge of the Physical (Boundary) Objects

One of the early discoveries learnt from the present thesis was the realization that in the engineering parlance, the terms 'information and knowledge' have been subsumed by one term only, and that term was 'technology'. For (Design) Engineers, the term 'technology' encapsulates both information and knowledge. The (Design) Engineers prefer to learn about new technologies through tangible evidences of prototypes, product samples, CAD models, or drawings. They prefer holding these items in their hands rather than consulting supplier brochures or websites (Culley, 1999; Distanont at al., 2012; Kopecka et al., 2010). In consequence, the concept of information and knowledge as intangible assets holds little meaning for the (Design) Engineers, because for them to be meaningful, information and knowledge need to be tangible.

In the literature, physical objects that facilitate the exchange of information and knowledge are known as 'boundary objects' (Carlile, 2002, 2004, Carlile and Rebentisch, 2003). The present thesis identified nine types of Physical (Boundary) Objects (Table 8.7) that were used daily, and thus attested to the hands-on approach of the (Design) Engineers to information and knowledge.

As a Multicase Theme, the Physical (Boundary) Objects were analysed (Section 8.3.3) in terms of their property of Representing, Learning, and Transforming knowledge (Carlile, 2002). In addition, the present thesis also examined the impact that the use of Physical (Boundary) Objects had on the information relationships of their users. This led to the discovery of an additional property, namely that of Evidencing. Table 8.7 provides examples when Physical (Boundary) Objects were found to evidence goodwill and trust to, and on behalf, of their users. The principle of 'Seeing is believing' (as in holding an object in one's hand) was found to be the guiding force behind the evidentiary function of Physical (Boundary) Objects.

9.1.1 Research contribution pertaining to Research Question 1

Having identified the property of Evidencing, the thesis extends the thinking about boundary objects in the field of design engineering and product development, started by Paul R. Carlile (2002, 2004).

The Reflective Comment (Box 8.3) and the Cross-case Assertion about Physical (Boundary) Objects (Section 8.5.3) make a linkage between the impact that Physical (Boundary) Objects have on the information relationships between their users and the formation of trust. The case evidence suggests that Physical (Boundary) Objects can be viewed as the physical embodiment of trust because they provide evidence about the competence and benevolence (goodwill) of the boundary object provider.

The use of Physical (Boundary) Objects in the FFE of NPD represents the phase of adoption in the utilization of the provider's information and knowledge.

9.2 **Answers to Research Question 2**

The second Research Question concerns the How of the information relationship, as reflected in the exchange and utilization of supplier information and knowledge at the micro-social level of the firm. Formulated as a result of literature research (Chapter 2), the Research Question 2 sought answers to:

> *How does an information relationship between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of supplier and customer firms work? How does the exchange of information and knowledge take place?*

The discussion of the thesis' findings that help answer the Research Question 2 pertains to the following three issues:

- Single Sourcing by choice;
- Social ties; and
- Trusted Weak ties.

Single Sourcing by choice

In the strategy of Single Sourcing by choice, the information relationship dyad usually consists of a (Design) Engineer of the customer firm and a Sales Engineer of the supplier firm, but may later be expanded to a team. The Sales Engineer who is familiar with the engineering practices of both the supplier and the customer firm is in a position to access the knowledge of R&D labs of his/her firm, and relate this knowledge to the customer's needs. In relating and transferring this often 'sticky' knowledge (Von Hippel, 1994; Szulanski, 2002), the Sales Engineer adopts the work style of a Knowledge Worker (Darr, 2002, 2003, 2006).

Although the Sales Engineers interviewed in the present thesis, were not familiar with the concept of a knowledge worker, they provided ample evidence of the concept in the way they described their work. They regarded themselves as *a new type of Sales Engineer*, someone who *connects (Design) Engineers with (Design) Engineers*, someone who *earns money by products, but in fact is selling knowledge.*

The Within-case Analyses (Chapters 4-7) found that the strategy of Single Sourcing by choice was in all four firms commonplace. The case evidence suggests that the firms are well aware of the risks of Single Sourcing in the FFE of NPD, but that the risks are not deterrent enough, when the utilization of supplier knowledge can result in a competitive advantage of the firm.

Social ties

Of the 22 Salient Issues (Table 8.1) identified in the Within-case Analyses (Chapters 4-7), nine Salient Issues were directly related to the role that social ties play in the information relationships between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineering.

The Cross-case Analysis of Salient Issues (Section 8.2) identified a further two more Salient Issues that were related to Social Ties in the exchange of information and knowledge. As a result, Social Ties became one of the four Multicase Themes.

In the Conceptual Framework (Figure 3.3 in Chapter 3), tie modality (i.e., the type of social tie) is depicted as a mechanism that lies at the core of the dyadic information relationships, and that is instrumental in the utilization of supplier information and knowledge taking place. The Conceptual Framework (Figure 3.3) offers a choice of three types of social ties: strong ties, weak ties and trusted weak ties. Each type of social tie results in a different information relationship, and holds different consequences for how supplier information and knowledge are utilized.

The weak ties facilitate access to new sources, but because weak ties are incidental and temporal, they do not lead to the utilization of information and knowledge that they help access. In contrast, the strong ties are good in the utilization of information and knowledge because they operate on the basis of reciprocity and mutual trust in knowledge sharing. The trusted weak ties are a hybrid form of social tie that facilitates both the access to and the utilization of information and knowledge.

The present thesis found no evidence of strong ties and weak ties at the micro-social level of the four focal firms. Therefore, it was necessary to review the Conceptual Framework to reflect this finding (Section 8.6). The final Conceptual Framework, shown in Figure 8.4, presents trusted weak ties as a sole mechanism for mediating the dyadic information relationship, and ultimately, the utilization of supplier information and knowledge.

The absence of weak ties and strong ties requires further explanation. The absence of weak tie relationships is given by the constraints of the thesis. The supplier firms participating in the study have all turned out to be the so-called preferred suppliers (i.e., firms that have regular, often long standing trading relationships with the customer firms). In consequence, the information relationships with preferred suppliers don't meet the definition of a weak tie relationship.

However, neither can the information relationship of Purchasers and (Design) Engineers with the preferred supplier's Sales Engineer be designated as a strong tie relationship despite the often close cooperation. The information relationship with the preferred supplier's Sales Engineer does not represent a strong tie relationship because unlike in strong tie relationships, it is not based on unconditional trust, and the duration of the relationship is not permanent or indefinite. Thus, even in cases of Single Sourcing when firms are bound together by intensive cooperation, the need to switch to dual or multiple sourcing (Faes and Matthyssens, 2009; Gelderman and Van Weele, 2003) is kept constantly under review.

With regard to internal social ties between the (Design) Engineers and the Purchasers, the case evidence shows that the relationship between these two functions evolved from a relationship of near antagonism to one of mutual respect for one another's expertise (Box 5.6), but that it nevertheless cannot be designated as a strong tie relationship.

Trusted weak ties

The Cross-case Analysis of the Multicase Theme of Social Ties (Section 8.3.1) was guided by the research of Stanko et al. (2007) who translated the original dimensions of tie strength, as defined by Granovetter (1973), into the context of business relations. The new dimensions of tie strength read as follows:

- Time (Length of relationships);
- Emotional intensity (Business relationship that goes beyond the economic transaction);
- Intimacy/Mutual confiding (Sharing of fine grained, sensitive, and confidential information through both formal and informal channels of communication); and
- Reciprocal services (Business partners take active responsibility for the partner's well-being, as well as their own. There exists a unity of interest and solidarity. Problems are solved jointly).

The dimensions imply but do not specify the role that trust plays in achieving the different manifestations of strong and weak ties. The case evidence (Section 8.3.1) shows that there is a great deal of overlap between the tie strength dimension of Emotional Intensity and the tie strength dimension of Intimacy/Mutual Confiding. For the two dimensions of tie strength to be productive, trust in the competence and benevolence of the dyadic partner is a necessary precondition.

Trust was also found to be the underlying theme in the other two dimensions of tie strength, namely: the dimensions of time (i.e., the length of relationships) and the dimension of reciprocal services.

The length of relationship, or frequency of contact, is conducive to trust building. For example, the choice for Single Sourcing can largely be explained by the duration of the contact. Supplier firms that have had long standing relationships with customer firms are able - through their know-how about the customer firm's policies and procedures - to help the customer firm save time and energy in the run up to new projects, and customer firms appreciate such supplier alignment to their needs.

Reciprocal services involve trust in expecting a trading partner to return a favour; i.e., having trust in that the help given to a firm to solve its problem will be reciprocated when needed.

When Stanko et al. (2007) and Granovetter (1973, 1982) defined the dimensions of tie strength, they both worked from the assumption that there were only two kinds of social ties: strong ties and weak ties. The concept of trusted weak tie had only been proposed in 2004 by Levin and Cross (2004). The concept holds that a trusted weak tie represents a hybrid form of social tie which combines the relational benefits of strong ties (trust, reciprocity, learning) and the structural benefits of weak ties (access to non-redundant and diverse information).

The four case studies in the present thesis show that in environments where both strong ties and weak ties are absent, but where the exchange of information and knowledge evidently occurs through social relationships, the concept of trusted weak tie is a useful mechanism to explain how the exchange and utilization of supplier information and knowledge takes place. The concept is useful because it makes a linkage between the dyadic information relationships and the benevolence and competence of dyadic partners. Thus, the concept of trusted weak tie not only explains how the exchange and utilization of information takes place, but it also explains why it takes place.

9.2.1 Research contribution pertaining to Research Question 2

The research on trusted weak ties is still recent (Abrams et al. 2003; Gubbins and MacCurtain, 2008; Levin et al., 2006, 2010). The present thesis' contribution to this fledging research is in finding evidence for the concept of trusted weak ties in a new context, namely, in the interpersonal information relationships in the FFE of NPD.

The final Conceptual Framework (Figure 8.4) used the concept of trusted weak ties as a causal mechanism with which to explain the exchange and utilization of supplier information and knowledge in the FFE of NPD. The trusted weak ties were also central to the formulation of the Cross-case Assertions about the Multicase Themes (Sections 8.5.1 - 8.5.4). The Cross-case Assertions, derived from the case evidence, illustrate the usefulness of the trusted weak tie concept in understanding how dyadic interpersonal information relationships function in the FFE of NPD.

9.3 Answers to Research Question 3

The third Research Question concerned the Why/Why not of the information relationship, as reflected in the exchange and utilization of supplier information and knowledge at the micro-social level of the firm. Formulated as a result of literature research (Chapter 2), the Research Question sought answers to:

Why do some information relationships between the individuals in the functions of (Design) Engineering, Purchasing, and Sales Engineers of supplier and customer firms lead to the utilization of supplier information and knowledge, and other do not?

The discussion of the thesis' findings that help answer the Research Question 3 pertains to the following two issues:

- actionable knowledge in relation to social ties; and
- trust in the dyadic information relationships.

Actionable knowledge in relation to social ties

The concept of Actionable Knowledge was identified through the literature review (Section 2.4.4). Developed by Cross and Sproull (2004), the concept holds that knowledge is actionable when it "leads to immediate progress on a current assignment or a project". Cross and Sproull (2004) proposed five components of actionable knowledge (solutions, referrals, problem reformulation, validation and legitimation) which they validated in the information seeking behaviour of 40 managers of a Big Five accounting firm in the US. Their research found that the social relationship between the knowledge seeker and the knowledge provider (a dyad) influenced who was sought out for which component of actionable knowledge. The concept of actionable knowledge helped explain why the processes of exchange and utilization of information and knowledge is neither time-bound nor automatic, but instead involves two independent stages of adoption and implementation. The case evidence suggests that being aware of (i.e., adopting) supplier information and knowledge will lead to implementation only if the information and knowledge come from a trusted source (a strong tie or a trusted weak tie), and the information and knowledge are actionable. This finding was taken into account in the final Conceptual Framework (Figure 8.4).

Trust in the dyadic information relationships

Trust emerged from the analysis of Salient Issues (Section 8.2) as one of the four Multicase Themes. The Cross-case Analysis of the Multicase Theme of Trust (Section 8.3.4) examined the case evidence from the four Within-case Analyses (Chapters 4-7) against the background of the Integrative Model of Dyadic Trust (Mayer et al., 1995) and its five components, shown in Figure 8.2. There were three reasons for choosing this particular model:

- the model conceptualizes trust as a social phenomenon between two parties, the Trustor and the Trustee;
- the model places the dyadic trust relationship in an organizational setting; and
- the model makes a distinction between trust and risk. "The need for trust only arises in a risky situation" (Mayer et al.,1995: 711).

By placing the five components of the Integrative Model of Dyadic Trust into the context of the Within-case Analyses (Chapters 4-7), and by interpreting the utilization of supplier information and knowledge as an outcome of a risk taking relationship (Section 8.3.4), it was possible to arrive at new insights about the role of trust in the dyadic information relationships.

The case evidence from the Within-case Analyses showed, that unlike in the Integrative Model of Dyadic Trust (Mayer et al., 1995), the outcome of a risk taking relationship has consequences not only for the perceived trustworthiness of the Trustee, but that a risk taking relationship also affects the perceived trustworthiness of the Trustor.

In the Integrative Model of Dyadic Trust (Mayer et al., 1995), the outcome of a risk taking relationship can be either positive or negative. The Feedback loop in the Model indicates that a negative outcome leads to a diminishing trust of the Trustor in the Trustee. However, there is no Feedback loop from the Trustee to the Trustor. Thus, the Model, although dyadic in name, presents the outcome of dyadic trust from the perspective of only one party in the dyad, namely the Trustor.

However, when placed in the context of dyadic information relationships in the FFE of NPD, the Model's Feedback loop can also hold a message for the Trustee. For example, in situations when the outcome of the utilization of supplier information and knowledge results in adoption only, whereas the Trustee expected to have his/her information and knowledge implemented. The Trustee may feel disappointed by this level of response, and in consequence, be reluctant to provide any information or knowledge to the Trustor in the future. Thus, from the viewpoint of the Trustee, the Feedback loop in the Integrative Model signals a disruption of the information relationship. From the viewpoint of the Trustor, however, the outcome is still positive: the Trustee is trustworthy, the information and knowledge were found useful (i.e., the received information and knowledge were adopted), but the implementation has been deferred until an unspecified date.

The research of Hansen et al. (2001), reported in the literature review (Section 2.4.3), has shown that there is a trade-off between providing information and knowledge and maintaining the ensuing information relationship. The Trustor approaches the Trustee because of the Trustee's perceived trustworthiness. If, however, the provided information and knowledge have not been implemented, the Trustee may draw a conclusion that he/she can use his /her time and expertise more efficiently elsewhere. Alternatively, the Trustee may accept the delayed implementation provided that he/she trusts the benevolence of the Trustor. However, as shown in Figure 8.2, the Integrative Model of Dyadic Trust (Mayer et al., 1995) views benevolence as a personal characteristic of the Trustee only. In contrast, the case evidence (Box 8.4) suggests that benevolence should be understood as a two-way relationship.

9.3.1 Research contribution pertaining to Research Question 3

Trust and the utilization of information and knowledge (the outcome of a dyadic information relationship) are intertwined. Using the Integrative Model of Dyadic Trust (Mayer, et al., 1995) produced new insights about the interpersonal dyadic information relationships. At the same time, the Cross-case Analysis of the Multicase Theme of Trust (Section 8.3.4) has led to the realization that it would be helpful if the Integrative Model were to incorporate the concept of trusted weak ties so as to capture the two-way responsiveness in the development of the information relationship between the Trustor and the Trustee.

The concept of trusted weak ties (Levin and Cross, 2004) and the Integrative Model of Dyadic Trust (Mayer et al., 1995) have in common their focus on benevolence as one of the drivers of trust. This common ground is not surprising given the fact that the definition of benevolence provided by Levin and Cross (2004) has been informed by the Integrative Model of Dyadic Trust (Mayer et al, 1995). There are differences, however. Whereas the Integrative Model of Dyadic Trust focuses on the antecedents and outcomes of trust, the concept of trusted weak tie focuses on the process in-between, on the relationship between the Trustor and the Trustee. Combining the two perspectives on the role of trust in interpersonal relationships is a logical step to consider.

Future research should therefore explore the possibility to designate the relationship in the Integrative Model of Dyadic Trust (Mayer, et al., 1995) as a trusted weak tie relationship (Levin and Cross, 2004) in order to give both the Trustor and the Trustee a voice, and to underline that benevolence is relational rather than personal property. The Feedback loop in the Model would then be no longer necessary.

9.4 **Research thesis' limitations**

The research limitations concern the thesis' data collection and data analysis.

Data collection

The data collection involved interviews, direct observation, and the study of the firms' documents. In total, 39 informants participated in the study representing the functions of (Design) Engineering, Purchasing, and Sales Engineering in customer and supplier firms.

It needs to be stated from the outset, that the scope and range of data collection is only in small part in the hands of the researcher. Frequently, the decisions about data collection involve a choice between accepting a case study as it stands, or attempting to have the data set enlarged and thereby running the risk of losing the case. It is a balance that the researcher needs to achieve. Moreover, it has to be borne in mind that when a firm brings the researcher in contact with its suppliers or customers, the firm is calling in a favour from its trading partners. At the same time, the firm is cautious not to over-extend the norm of reciprocity, or put its relationship with the trading partner in jeopardy.

The data collection in the present thesis is characterized by unevenness in data distribution. For example, the representation of the functions of (Design) Engineering, Purchasing, and Sales Engineering across the four firms shows fluctuations (Table 3.5 in Chapter 3). In Firm D, the function of Purchasing is represented by four informants, whereas Firms A and B have one informant each for the Purchasing function, and Firm C has none (Purchasing in Firm C is a back office function supported by an e-procurement system). The uneven representation is also evident at the inter-firm level where the participants from the focal firms outnumber the representatives from the supplier and customer firms.

Given the case evidence of the role of the Sales Engineer as a Knowledge Worker (Darr, 2002, 2003, 2006), it would have been interesting to investigate more broadly the information relationships at the supplier end. For example, to talk to the supplier's Product Managers or R&D personnel whose 'sticky' knowledge ((Von Hippel, 1994; Szulanski, 2002) the Sales Engineer helps transfer to the (Design) Engineers of the customer firm. However, extending the field work to supplier manufacturing sites would have resulted in foreign travel, extra costs and time, all of which was beyond the means of the present thesis.

Data analysis

The data analysis consisted of transcribing (and translating) interviews and field notes, coding and categorizing the data, finding patterns and themes as they emerged from the four Within-case Analyses and the Cross-case Analysis, and making tentative assertions about the cases through Reflective Comments. The case evidence has been summarized and made comparable with the help of tabular displays (Miles and Huberman, 1994).

In the present thesis, the data analysis has been the work of one person, the author of the thesis. It is possible that multiple interpretations of data by independent researchers would have led to different choices of themes and patterns in the data, but the present thesis was guided by the advice of Robert E. Stake (2006: 18) that:

> *Most multicase studies are so complex that they almost need to be done by one person!*

The threat to validity and bias has been countered by two precautionary measures. First, by regularly consulting the research findings with the thesis supervisors. Secondly, by sending the transcripts of both the interviews and the written up case reports to the case informants for validation.

9.5 **Suggestions for further research**

Stake (2006) points out that the researcher should pay particular attention to outliers (i.e., deviant themes or findings) because they may represent a potential area for future research. The present thesis has identified three such outliers. Two outliers emerged as a result of the Salient Issue analysis (Section 8.2), namely:

- Engineering educational background of Purchasing staff; and
- Audits and Supplier Development as mechanisms for the exchange of information and knowledge.

The subject of the case vignette in Section 6.3, illustrating the development of the Gripper component in Firm C, is proposed as a third outlier. A generic title for the research in this area could be:

- The exchange of information and knowledge in Disruptive Innovations.

Engineering educational background of Purchasing staff

While the educational background of Purchasing staff emerged as a Salient Issue in the present thesis, it is certainly not an under researched area. Given the number of professional organizations worldwide that sponsor research into the Purchasing's role in supply chain management, it is not surprising that there is a constant stream of research on the current status and future directions of the profession (Carter and Narasimhan, 1996; Ramsay and Croom, 2008; Rozemeijer, 2008; Van Weele and Rozemeijer, 1996). Such studies discuss and review not only the educational background of Purchasers, but also job appointments and tenure, promotion, and reporting lines within the firm (Johnson and Leenders, 2009).

The literature review in Chapter 2 (Section 2.3.2) has shown that the function of Purchasing is well represented in the literature. In fact, Purchasers are frequently the only group in the firm that is interviewed in the studies of customer/supplier relationships.

The present thesis found that although Purchasers were undeniably the first line of contact for suppliers, other lines for exchanging information and knowledge with suppliers existed and were formed in parallel. Since the nuts and bolts of NPD are figuratively and literally in the hands of (Design) Engineers, the interpersonal information relationships between the (Design) Engineers of customer firms and the Sales Engineers and (Design) Engineers of supplier firms deserve more research.

Audits and Supplier Development

The research area of Audits and Supplier Development is a field of inquiry in which Purchasing initially took the lead. As discussed in Section 2.3.2 of the literature review, Audits and Supplier Development started as a responsibility of Purchasers. The aim was to bring the supplier firm to a higher level of performance so as to ensure costs reduction and quality control. With the outsourcing of component design, other issues, such as time to market and knowledge exchange with suppliers, became a matter of concern (Giannakis, 2008; Krause and Ellram, 1997; Krause et al., 2007; Modi and Mabert, 2007).

The question arises whether, given the increasing complexity of product technology, the Purchasers, or the Quality Control Engineers (in the present thesis only Firm B had one) should continue to do this work alone. In Firm B, the (Design) Engineers were strongly in favour of cross-functional teams when performing an Audit of a supplier firm: they wanted to be part of the auditing process.

It could be argued that just as at the firm level, some firms are proactive and some are reactive in their Supplier Development (Krause et al., 1998), so at the functional level, the individuals performing the Audit work would adopt a proactive or reactive approach. It could be further assumed that the (Design) Engineers because of their frequent contacts with customer firms would adopt a proactive approach because they are in a better position to anticipate customer needs. The example in Firm A, concerning the identification of new supplier technologies (Section 4.2.1) shows how an intensive exchange of information and knowledge between the (Design) Engineers of customer and supplier firms, based on identification trust (Lewicki and Bunker, 1996), resulted in a joint proposal for a new solution to the customer.

The current research on Supplier Development is mostly carried out at the level of the firm, and its outcome is linked to the customer firm's (financial) performance. However, the success of Supplier Development in terms of the knowledge accessed, exchanged, and used is ultimately dependent on the individuals involved, and their respective information relationships.

The present thesis has only addressed the information relationship in the FFE of NPD between the (Design) Engineers and the supplier's Sales Engineers, in their role of a knowledge workers (Darr, 2002, 2003, 2006). However, behind the Sales Engineers, there is an infrastructure of supplier knowledge (R&D labs, Product Managers) that the customer's (Design) Engineers could benefit from if they were to actively take part in Supplier Development.

As reported in Section 2.3.2 of the literature review, Toyota (Sako, 2004) adopted a two-pronged approach with regard to Supplier Development. In Toyota, Purchasers and Engineering Division work independently of one another in Supplier Development projects so as not to make price negotiations and knowledge transfer with suppliers intertwined. The research on cross-functional sourcing teams (Driedonks et al., 2010), and a recent online survey of 681 firms in Europe and North America (Bengtsson et al., 2013) have shown that cross-functionality in supplier management is gaining ground.

To study cross-functionality in Supplier Development could produce new insights into whether and how Supplier Development can function as a platform for the exchange of information and knowledge between the (Design) Engineers of customer firms and the (Design) Engineers of supplier firms, and how such information relationships contribute to the FFE of NPD.

Related to the issue of Supplier Development is the practice of 'preferred suppliers'. The case evidence of the present thesis indicates that currently the selection criteria are geared towards avoiding financial and operational risks. It is astonishing that supplier's knowledge is not seen as an assets that a 'preferred' suppliers ought to have, although a Mission Statement of the customer firm may do so (e.g., Firm A, Chapter 4). More research is needed about the linkage between the selection of suppliers and their strategic focus on innovation (Wynstra et al., 2010).

Do all preferred suppliers have an explicit innovation strategy and a trust mindset (Lewicki and Bunker, 1996) that are needed for Supplier Development, and the ensuing exchange of information and knowledge?

The exchange of information and knowledge in Disruptive Innovations

In the context of the FFE of NPD, the research topic of Disruptive Innovations is particularly interesting because it represents the fuzzy front end in its purest form. Disruptive Innovations per definition do not have a market, and do not have customers (Miller et al., 2006). New features or functionalities are not instantly appreciated because they are compared with the existing applications. The project on the Gripper component (Case vignette, Section 6.3) illustrates that Disruptive Innovations are a side-line activity for firms.

The case vignette shows the crucial role that the exchanges of information and knowledge played in getting a project off the ground, and bringing it to completion. Other projects in Firm C involving Disruptive Innovations were less successful.

A case study by Rydell (2010) revealed that the biggest stumbling block in developing a prototype to a commercial product was the vast amount of information that the (Design) Engineers of the Subsidiary firm had to sift through, while at the same time being confronted with inadequate communication with the R&D Engineers from the Headquarters of Firm C.

Given the potential of Disruptive Innovations to create new markets, and considering the uncertainty, complexity, and equivocality of new technology applications, the research on how the (Design) Engineers seek and use information could help improve the organization of Disruptive Innovation projects so that the projects are brought to completion faster, and with less of a risk.

Future research, both in the field of Supplier Development and Disruptive Innovations, should adopt as the level of analysis the micro-social level of the firm (Knorr-Cetina, 1981) which allows for an on-the-ground investigation of the face-to-face interactions, and provides the researcher rich data to work with. Chapter 2 (Section 2.1) of the present thesis, cited Frishammer and Ylinenpåå (2007: 442) calling for more detail in the research on management of information in NPD, more richness in data concerning how and why information and knowledge were being used in NPD. The present thesis bears witness to the fact that the data can be rich as well as plentiful. However, rich data are also rewarding because they bring about in-depth insights into the nature of information relationships and allow to focus on specific situations.

9.6 **Managerial implications**

The findings of the present thesis point towards the role of social ties as a mechanism enabling and facilitating the utilization of supplier information and knowledge in the FFE of NPD. A firm's Management reaction to such findings might be a wish to strengthen social ties with suppliers. Taking such response would entail an implicit recognition that the supplier firms have valuable information and knowledge to contribute.

The findings of the present thesis, however, revealed that Management of NPD projects had the tendency to downplay the contribution of suppliers to the FFE of NPD. Although firms' mission statements and websites often proclaim the need and desire for close collaboration with suppliers, the micro-social level of the firm shows a different picture. The actual exchange and utilization of supplier knowledge and information take place at the level of (Design) Engineers of customer and supplier firms. The contacts are often mediated by the supplier's Sales Engineers, and are directed at solving immediate design problems at hand. Thus, the exchanges are purposeful, but with no long term vision for extending the firm's knowledge base. In the eyes of NPD Management, such temporary contacts are viewed as part of normal business interactions.

The first managerial implication of the present thesis is therefore that firms need to acknowledge supplier firms as a knowledge source, and not only as a trading partner. The evidence from the four case studies of the present thesis indicates that such increased awareness is more likely to arise as a result of a bottom-up process, with (Design) Engineers taking the lead. The occurrence of Single Sourcing is a case in point. The initiative for establishing Single Sourcing of a product part had always come from the (Design) Engineers who knew from experience that being the first or the only users of a particular piece of supplier knowledge could result in a competitive advantage.

The second managerial implication can be found in the thesis' findings with respect to the role of social ties in the information relationships between customer and supplier firms at the micro-social level of the firm. The thesis points the way how a focus on interpersonal information relationships may help solve knowledge-related problems in the areas of customer/supplier relationships, such as outsourcing and the selection of preferred suppliers or preferred customers.

Taking the example of outsourcing first, a key problem of outsourcing, when viewed from the knowledge transfer perspective, is that increasing supplier responsibility for customer's NPD does not necessarily lead to the development, or sharing, of new knowledge. Quite the opposite may be true. As showed in the literature review in Chapter 2 (Section 2.2.3), the leakage of proprietary knowledge, or knowledge hollowing-out, are the most frequently cited risks of collaborative NPD (Becker and Zirpoli, 2003; Ettlie and Pavlou, 2006; McIvor and Humphreys, 2004, Takeishi, 2002).

The presence of trust has been recognized as a necessary precondition for supplier involvement in NPD (Bstieler, 2006; Johnston et al., 2004; Ragatz et al., 1997).

In the present thesis, trust emerged as a property of social ties. The implication here is that rather than tackling the risks of outsourcing by adopting, for example, the approach of knowledge partitioning (Takeishi, 2002), Management should view outsourcing as a form of a dyadic information relationship. The case evidence shows that exchanging expertise with another party takes time and trust. Therefore, Management should empower and award the employees for investing time and effort to build social ties with suppliers (Hald et al., 2008; Sobrero and Roberts, 2002; Stanko et al., 2007). Management should be aware that having a solid social network represents a new type of capability that is difficult to replicate (Croom, 2001; Gulati, 1995; Gulati et al., 2000), and which may safeguard the firm against potential malpractices (Granovetter, 1985).

Adopting a relational approach to better understand the capabilities of future business partners is also applicable in the selection of preferred suppliers and preferred customers. The current selection procedures are based on operational performance data, that is, on the tangible benefits of cooperation. The procedures were originally designed as an upgrade alternative to an arm's length relationship. However, in the current economy, a competitive advantage is achieved by capabilities based on intangible assets, such as knowledge creation and combination in the NPD process that are difficult to replicate (Barney, 1991; Kogut and Zander, 1991). Therefore, firms should select the preferred suppliers and customers for their innovativeness (Azadegan et al., 2008, Wynstra, et al., 2010). Here it is worth remembering that the innovativeness of the firm is derived from the innovativeness of the firm's employees (Foss, 2007), whereby social ties act as formal and informal information channels (Croom, 2001; Hansen, 1999, Hansen et al., 2001). Thus, the value of social ties is that they represent a linkage between individual and firm-level innovativeness (Foss, 2007).

In conclusion, if NPD Management accepts that supplier information and knowledge represent a valuable external resource, then the deployment of social ties to access and disseminate that knowledge offers the firm a complementary approach to managing customer/supplier relationships and a new source of competitive advantage.

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list of tables, figures and boxes

Tables

Figures

Boxes: Reflective Comments

Boxes: Reflective Comments & Salient Issues

appendices

Appendix 1: Executive Summary

The PhD project focuses on how information from supply chain (sourcing information) is utilized in new product development. We are particularly interested in the contribution that sourcing information can make in the idea generation phase of new product development, the so-called fuzzy front end.

The reality of global supply chains is that materials are sourced globally. This is even more true of sourcing information. Information about suppliers, their products and new technologies can come from all over the world. The Internet and ICT connectivity created a new information-seeking environment, one in which sourcing information is no longer a result of a specific dyadic relationship between the firm and its supplier, but has become part of an ongoing and cumulative information flow in the firm's supply chain (Tomita and Fujimoto, 2006). Our view of the supply chain is therefore that it represents an information network.

Product development has been described as: “a process of gradually building up a body of information until it eventually provides a complete formula for manufacturing a new product” (Smith and Reinertsen, 1998:167). New product development has come to be understood as recombination of knowledge and relationships, both of which have increasingly become externally oriented. The NIH (not invented here) syndrome becomes a Need not be Invented Here opportunity (Hansen, 1999). Stretching the firm’s knowledge boundaries beyond its production boundaries has also brought about an awareness that social networks belong to the firm’s business environment.

In investigating the search for and utilization of information from the product development supply chain, the case study will draw on Social Network Theory (Granovetter, 1973). The theory holds that the outcome of interpersonal activities, such as information search, exchange, and utilization, is determined by the frequency and intensity of contact, the so-called tie strength, between the participants of the network. Granovetter (1973) specified two types of interpersonal ties: strong ties and weak ties. Levin and Cross (2004) have identified a third type: the trusted weak tie.

The PhD project aims to explore the properties of ties through case studies. The network participants in our case study will consist of product development staff, product/project managers, purchasing staff and their contacts in the supply chain. Strong ties, weak ties, and trusted weak ties are seen as mechanisms through which the search, exchange, and utilization of supply chain information take place.

The case study will focus on the properties of ties. In particular, it will study how the differences in tie properties affect the tie capacity to find novel information and to initiate learning. By learning is understood the acceptance and utilization of new ideas by the network participants. An essential precondition to learning is trust. The tie properties influence learning in different ways.

Strong ties typically operate within small groups (e.g. product development team). They prefer to engage in the utilization of information which is already available within the group and which is well tried. In information exchange, trust and reciprocity are expected. Frequent interaction and mutual trust found in strong tie relationships are conducive to learning and information sharing. A disadvantage of a strong tie relationship is that, over time, the intense information exchange brings about an overlap in knowledge among the exchange partners.

Weak ties, on the other hand, are infrequent relationships between two parties in which trust and reciprocity are not required. Therefore, weak ties are not conducive to learning and information sharing. However, weak ties are known to lead to novel and unexpected information. An example of a weak tie relationship would be an incidental search on the Internet by product designer looking for product-related information.

Trusted weak ties are weak ties operating in an environment in which the information sources are perceived by the information seeker to be trustworthy, benevolent, and competent. As a result of these additional relational characteristics of information sources, information searches performed in such conditions lead not only to novel information (property of weak ties), but also enable learning (property of strong ties). In other words, the trusted weak tie is a hybrid tie which in conditions of the benevolence-and-knowledge based trust incorporates the properties of both strong and weak ties.

The case study makes a supposition that the relationship between members of the purchasing staff and their contacts in the product development supply chain represents a trusted weak tie relationship. Equally possible is that the case study will discover other new variants of trusted weak tie relationships.

The case study seeks to find evidence that information from the product development supply chain, as provided by purchasing staff (or other information brokers within the firm) to product development contributes to learning in the sense that it helps trigger the generation of new product ideas.

A further conjecture of the case study is that by acquiring supply chain information in the fuzzy front end of product development, the supply chain information can act as a kind of forerunner (proxy) to timely supplier involvement in product development. It can pave the way for aligning supplier capabilities to product development objectives, and thus to a successful partnership in the future.

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Appendix 2: Questionnaire version 2

Case Study Questionnaire
(Please tick the appropriate box on the left.)

Part 1: Your company's relationships with the supply chain

1. Would you describe your company's contacts with suppliers as:
[ ] focused solely on ordering and purchasing;
[ ] exchanging product-related information which may or may not lead to a transaction;
[ ] consulting/integrating suppliers in product development.

2. Can you estimate, in percentages, how much time does your company currently spend on:
material sourcing (focused on purchasing materials to support the manufacture of existing products) -------- **%**
information sourcing/monitoring (focused on identifying innovative product and material ideas in the supply chain**)** -------- **%**

3. In your experience, how is information sourcing/monitoring in your company prioritized? (More answers are possible: #1=first priority; #2= second priority; #3=third priority).
[ ] the company's preferred suppliers (the supply base);
[ ] the supply chain market in general;
[ ] external sources other than the supply chain.

Part 2: Information from the supply chain

4. Do you know examples when information from the supply chain has led to <u>one or more</u> of the outcomes listed below? If so, how frequently does this happen? (5 = very frequently; 4= frequently; 3= sometimes; 2 = infrequently; 1 = never)
[ ] reduced development costs;
[ ] reduced product development cycle time;
[ ] improved product quality;
[ ] reduced purchase price costs;
[ ] new product ideas;
[ ] don't know of any examples.

5. How is information from the supply chain being disseminated at the moment? Is it disseminated through:
[ ] regular formal cross-functional (with members of other departments) meetings?
[ ] regular informal cross-functional meetings (lunch, coffee break)?
[ ] designated point of contact (e.g., one person is responsible for disseminating information from the supply chain)?
[ ] IT system (other than e-mail) which allows internal information exchange?

6. **How would you rate information from the supply chain that you yourself use regularly on the scale 1-10 (10 being the highest rating) using the nine criteria for information quality (more answers are possible). Please encircle you answer.**

accuracy *(reliable);*
1 2 3 4 5 6 7 8 9 10

relevance *(to the company's product development projects);*
1 2 3 4 5 6 7 8 9 10

completeness *(includes product visuals such as drawing, models, photo's , etc.);*
1 2 3 4 5 6 7 8 9 10

timeliness *(current);*
1 2 3 4 5 6 7 8 9 10

diversity *(information is different from the information you already have);*
1 2 3 4 5 6 7 8 9 10

accessibility *(information can be accessed easily);*
1 2 3 4 5 6 7 8 9 10

understandability *(no extra effort is needed to 'translate' the information);*
1 2 3 4 5 6 7 8 9 10

content personalization *(information is coached to meet personal requirements);*
1 2 3 4 5 6 7 8 9 10

dynamic content *(information is updated regularly and is searchable)*
1 2 3 4 5 6 7 8 9 10

Part 3: Your information environment

7. **Please list <u>at least five</u> of your favourite (supplier) information sources in ascending order (i.e., the most important source first). These could be websites, databases, trade organizations, research institutions, etc. Please be as specific as you can (don't just write down 'the Internet'). For 'People contacts' see Question 8.**

7a ……………………………………………………………………………………….

7b ……………………………………………………………………………………….

7c ………………………………………………………………………………………..

7d ……………………………………………………………………………………... .

7e ………………………………………………………………………………………

7f ……………………………………………………………………………………….

7g ………………………………………………………………………………………..

7h ……………………………………………………………………………………….

8. **Please list <u>at least five</u> of your favourite personal contacts, outside and inside the company, (in ascending order) and their background (e.g., their function or field of expertise):**

8a ……………………………………………………………………………………

8b ……………………………………………………………………………………

8c ……………………………………………………………………………………

8d ……………………………………………………………………………………

8e ……………………………………………………………………………………..

8f ……………………………………………………………………………………..

8g ……………………………………………………………………………………..

8h ....

9. **Can you estimate, in percentages, how much time in your job do you spend on information gathering? …………………..%**

10. **How much of the above time is devoted to:**
monitoring known information sources (keeping abreast of the latest developments). ………………….%
goal oriented searches (searching in order to resolve a problem)…….……..%
browsing (searching with no specific purpose in mind) …….………..%.

Part 4: Your information behaviour

11. **Listed below are nine generic information seeking situations. Please relate each situation to your own work, and indicate which of your favourite information sources would be your 1st, 2nd, and 3rd choice when starting information search.**

I. **When I am looking for information on <u>facts (know-what)</u>**
My 1st choice of information source would be ……………………………..
My 2nd choice of information source would be ………………………………
My 3rd choice of information source would be ……………………………..

II. **When I am looking for information on how something is done <u>(know-how)</u>**
My 1st choice would be ……………………………………………………..
My 2nd choice would be ……………………………………………………
My 3rd choice would be …………………………………………………….

III. **When I am looking for information on <u>the best person to turn to (know-who)</u>**
My 1st choice would be …………………………………………………….
My 2nd choice would be ……………………………………………………
My 3rd choice would be ……………………………………………………

IV. When I am looking for information on why something is the case (<u>know-why</u>)

My 1st choice would be ……………………………………………………….
My 2nd choice would be ………………………………………………………
My 3rd choice would be ………………………………………………………

V. When I am looking for information on what would happen if (<u>know-what if</u>)

My 1st choice would be ……………………………………………………….
My 2nd choice would be ………………………………………………………
My 3rd choice would be ………………………………………………………

VI. When I am looking for first-hand information on what happened (<u>know-what was</u>)

My 1st choice would be ……………………………………………………….
My 2nd choice would be ………………………………………………………
My 3rd choice would be ………………………………………………………

VII. When I am looking for information to help me formulate a problem (<u>defining problem dimensions</u>)

My 1st choice would be ……………………………………………………….
My 2nd choice would be ………………………………………………………
My 3rd choice would be ………………………………………………………

VIII. When I ma looking for information to <u>verify the accuracy</u> of my information. Am I on the right track?)

My 1st choice would be ……………………………………………………….
My 2nd choice would be ………………………………………………………
My 3rd choice would be ………………………………………………………

IX. When I am looking for information to <u>justify my understanding</u> of the problem.

My 1st choice would be ……………………………………………………….
My 2nd choice would be ………………………………………………………
My 3rd choice would be ………………………………………………………

12. What do you do with the results of your information search that you, yourself, have initiated? (more answers are possible). Do you

[ ] keep it to yourself and see it as a chance to build up your expertise?
[ ] pass it on to someone else who might benefit?
[ ] wait until it is specifically requested?
[ ] share the information you found with the colleagues of your department?

Part 5: Your level of involvement in development projects

13. To what extent do you participate in the product development process?

[ ] do you sit in the project meetings as an invited person?
[ ] do you take part in the project decision making?
[ ] your advice is sought, but you are not sitting in the meetings;
[ ] do you provide unsolicited advice?

14. Would you describe your relationship with project leaders as one which is based on:

[ ] recognition of mutual knowledge and expertise;
[ ] identification with the project (‘We are in this project together’);
[ ] mutual trust;
[ ] benevolence (goodwill, motivation);
[ ] reciprocal information sharing.

15. In your view, how much do product development projects draw on internally generated knowledge and experience as opposed to knowledge and experience generated outside the company?

Internally generated knowledge and experience ……….%
Externally generated knowledge and experience ……….%

16. Looking back at past projects, has the dependence on internally generated knowledge been increasing or decreasing?

[ ] increasing
[ ] decreasing

Part 6: Your comments and/or suggestions

17. Is there a question/issue which in your view is relevant but which you did not find in this questionnaire? If so, would you please jot down the question(s) in a few words?

Part 7: General information

Please state your:

18. Name, job title, and company name:

19. Gender
[ ] masculine; [ ] feminine.

20. Education:
[ ] business orientation; [ ] technology orientation.

21. Number of years in the current position:
[ ] less than one year; [ ] 1-3 years; [ ] 3-5 years; [ ] more than 5 years.

22. Last previously held job function(s):

Contact Information:

Please let us know your phone number, e-mail address, and also when you would be available for a 60-minute interview.

Phone:

E-mail:

Interview dates/time:

Please return this questionnaire to J.A.Kopecka@tudelft.nl

THANK YOU FOR YOUR COOPERATION!

Appendix 3: Open Axial Coding

OPEN CODING: total number of codes: 177
(Numbers in brackets indicate the code frequencies).

AXIAL CODING: There are 44 categories (written in capital letters) and 118 subcategories (written in lower case letters).
In addition, there are 15 property/dimension codes.

NOTE: The property/dimension codes refer to a property which is a general or specific characteristic of a (code) category and/or refer to a dimension which denotes the location of a property along a continuum (Strauss and Corbin, 1998).

Business_case (55) This is a property/dimension code
COMMUNICATION_CHANNELS(45)
COMPETITION
Competitive_advantage (21)
Competitors (31)
Core_business (11) This is a property/dimension code
CULTURE (8)
DRAWINGS (39)
DRIVERS_PRODUCT DEVELOPMENT All drivers are property/dimension codes.
Drivers_Competition_driven (7)
Drivers_Customer_driven (35)
Drivers_Market_driven (21)
Drivers_Technology_driven (43)
ENGINEERS_INFORMATION
Engineers_information_behaviour (73)
Engineers_information_sources (90)
Engineers_information_sources_database (40)
Engineers_information_sources_persons (33)
Engineers_types_of (18) This is a property/dimension code
Feedback (18) This is a property/dimension code
Frequency (76) This is a property/dimension code
INTERNET (33)
KNOWLEDGE_SHARING_KNWLS (FOCAL_FIRM)
KNWLS_engineering_focal_firm_info_diss (57)
KNWLS_engineers_focal_firm_meetings (46)
KNOWLEDGE_SHARING_KWLS (INTER_FIRM)
KNWLS_engineers_customer_firm(4)
KNWLS_engineers_customer_focal_firm_tests (29)
KNWLS_engineers_customer_suppliers (27)
KNWLS_engineers_customer_suppliers_meeting (13)
KNWLS_engineers_focal_firm_customer (44)
KNWLS_engineers_focal_firm_suppliers (102)
KNWLS_engineers_focal_firm_suppliers_meeting (52)
KNWLS_engineers_focal_firm_suppliers_tests (52)
KNWLS_engineers_supplier_firm (8)
Location_distance (38) This is a property/dimension code
MANAGEMENT DECISION MAKING (34)

MANUF_MANUFACTURING_PROCESS
Manuf_Plant (20)
Manuf_process_criteria (15)
Manuf_process_improvements (43)
Manuf_process_lessons_learned (9)
Manuf_process_overview_tools (45)
Manuf_process_phases (55)
Manuf_process_phases_trade_studies (43)
Manuf_process_product (13)
Manuf_process_technology (28)
Manuf_process_trends (13)
MANUF_TOOLS &_TOOLING
Manufacturing_tooling (21)
Manufacturing_tools (34)
Manufacturing_tools_support_software (27)
MATRIX ORGANIZATION
Matrix_organization (8)
Matrix_organization_problems (9)
OPINIONS
Opinion_negative (176) This is a property/dimension code
Opinion_positive (46) This is a property/dimension code
OUTSOURCING (29)
PATENTS (25)
PERSONNEL_CHANGES (23)
PP_PREFERRED_SUPPLIERS
Preferred_suppliers (63)
Preferred_suppliers_definition (21)
PROTOTYPES (53)
QUALITY_CERTIFICATION
Quality_certification_process (65)
Quality_certification_process_QPL (12) QPL=quality product listing
Quality_certification_process_tests (42)
Quotation (50) This is a property/dimension code
R_&_D_CUSTOMER
R_&_D_customer (10)
R_&_D_customer_motives (18)
R_&_D_financing (51)
R_&_D_FOCAL_FIRM
R_&_D_focal_firm (38)
R_&_D_focal_firm_customer (70)
R_&_D_focal_firm_motives (96)
R_&_D_focal_firm_phases (47)
R_&_D_focal_firm_supplier (103)
R_&_D_focal_joint_engineering_bureaux (26)
R_&_D_Focal_joint_universities_institutes (37)
R_&_D_meetings (25)
R_&_D_SUPPLIER
R_&_D_supplier (32)
R_&_D_supplier_customer (53)
R_&_D_supplier_incremental (37)
R_&_D_supplier_motives (51)

REL_RELATIONSHIPS_INTER_FIRM_LEVEL
Rel_relationships_focal_firm_customer (96)
Rel_relationships_focal_firm_customer_legal (59)
Rel_relationships_focal_firm_supplier (66)
Rel_relationships_focal_firm_supplier_legal (49)
Rel_relationships_supplier_customer (65)
Rel_relationships_supplier_customer_legal (20)
Rel_relationships_supplier_customer_meetings (10)
RELATIONSHIP_HISTORY (61)
RELATIONSHIP_INITIATIVE
Relationship_Initiative_customer (14)
Relationship_initiative_engineering_focal_firm (34)
Relationship_initiative_suppliers (32)
RELATIONSHIP_TIES
Relationship_ties_focal_firm_customer (11)
Relationship_ties_focal_firm_suppliers (23)
Relationship_ties_intra_firm (29)
Relationship_ties_sales_engineer (10)
RELGL_RELATIONSHIPS GROUP LEVEL
Relgl_customer_engineering_suppliers (19)
Relgl_customer_engineering_suppliers_meeting (8)
Relgl_customer_Engineering_suppliers_visits (8)
Relgl_customer_purchasing_suppliers (16)
Relgl_distributors (8)
Relgl_focal_firm_engineering_customer (27)
Relgl_focal_firm_engineering_customer_visits (24)
Relgl_focal_firm_engineering_purchasing (88)
Relgl_focal_firm_engineering_sales (33)
Relgl_focal_firm_engineering_suppliers (44)
Relgl_focal_firm_engineering_suppliers_visits (34)
Relgl_focal_firm_purchasing_distributors (6)
Relgl_focal_firm_purchasing_suppliers (55)
Relgl_focal_firm_purchasing_suppliers_logistics (17)
RISK_MANAGEMENT (17)
Serendipity (15) This is a property/dimension code
SOURCING_COMMITTEE (28)
STANDARDS
Standardization (18)
Standardization_commitee (18)
SUPPLIER_AUDITS (24)
SUPPLIER_DEVELOPMENT (21)
SUPPLIER_INTEGRATION
Supplier_integration_in_PD (58)
Supplier_integration_in_PD_timing (27)
SUPPLIER_PARTICIPATION STRATEGY (68)
SUPPLIER_PD_INFORMATION (Product Development)
Supplier_PD_information dissemination (81)
Supplier_PD_information_websites (34)
SUPPLIER_PRICE_POLICY (38)
SUPPLIER_SEGMENTATION_STRATEGY (15)
SUPPLIER_SELECTION

Supplier_selection_choice_limitations (46)
Supplier_selection_criteria (55)
Supplier_selection_parallel_sourcing (11)
Supplier_selection_second_source (51)
Supplier_selection_single_source (61)
SUPPLIERS_PRODUCT_PARTS
Suppliers_product_parts_assembly_time (24)
Suppliers_product_parts_costs (87)
Suppliers_product_parts_costs_standardized (44)
Suppliers_product_parts_quality (22)
Suppliers_product_parts_selection (77)
SUPPLIERS_SALES_ENGINEERS
Suppliers_sales_engineers_contact_frequency (35)
Suppliers_sales_engineers_contact_quality (41)
Suppliers_sales_engineers_contacting_engineers (63)
Suppliers_sales_engineers_contacting_purchasing (17)
Suppliers_sales_engineers_intern_meetings (45) intern= within the supplier firm
Suppliers_sales_engineers_project_facilitator (46)
TEAMS
Teams composition (35)
Teams_formation (42)
Teams_integrated (30)
TRADE_SHOWS (66)
TRIADS (three companies involved in an activity together)
Triad_versus_dyad (14)
Triad_certification (4)
Triad_conflicts (11)
Triad_engineering_design (39)
Triad_engineering_design_meetings (6)
Triad_product_parts_selection (21)
Troubleshooting (12) This is a property/dimesnion code
TRUST
Trust_ethics (5)
Trust_NPD_confidentiality (13)
Trust_NPD_cooperation_extern (11)
Trust_NPD_cooperation_intern (3)
Trust_NPD_process_control (8)
Trust_NPD_research (4)
Trust_past_experience (4)
Trust_personal_relationships (8)
Trust_supplier_selection (14)

Appendix 4: Selective Coding

Selective coding involves selecting and grouping Core Categories that reflect the central phenomena under study. Selective coding consists of two stages. First stage consists of drawing Core Categories from the Open & Axial Coding List (Appendix 3) and regrouping them. Second stage consists of relating and subsuming the Core Categories into 3-4 Central Categories.

The selected seven core categories are presented below in tables consisting of five columns. The first column contains the axial code categories from which the new core category originates. The second column introduces the name of the core category. The third column provides a scope note of the core category. The fourth column lists key literature pertaining to the research issues that relate to the core category. The fifth and last column provides an indication of what the core categories mean in terms of the present thesis' practical and theoretical contribution.

The seven Core Categories are:

- Information transfer facilitators (Core Category 1);
- Supplier capabilities (Core Category 2);
- Knowledge creation, intra-firm group level (Core Category 3);
- Information relationships, intra-firm group level (Core Category 4);
- Knowledge creation, inter-firm group level (Core Category 5);
- Information relationship, inter-firm group level (Core Category 6); and
- Trust (Core Category 7)

Appendix 4 concludes with the formulation of four Central Categories.

Core Category 1: Information Transfer Facilitators

Codes (The numbers in brackets indicate the code frequencies).	Core Code	Scope Core Code	Relationship with the Literature	Contribution Thesis
Communication_Channels (45) **Competitors (31)** **DRAWINGS (39)** **Engineers_information_sources (90)** **Engineers_information_sources_ database (40)** **Engineers_information_sources_ persons (33)** **INTERNET (33)** **Manuf_process_overview_tools (45)** **Manuf_process_phases_trade_studies (43)** **Manufacturing_tools_support_software (27)** *Opinion_negative (176) This is a property/dimension code* *Opinion_positive (46) This is a property/dimension code* **PATENTS (25)** **PROTOTYPES (53)** **SOURCING_COMMITTEE (28)** **Standardization_commitee (18)** **Supplier_PD_information_websites (34)** **Suppliers_sales_engineers_contact_ frequency (35)** **Suppliers_sales_engineers_contact_ quality (41)** **Trade shows (66)** **TRUST (70)**	**<u>Information Transfer Facilitators</u>**	***Information transfer facilitators are communication channels, objects, people, events, or documents that enable/facilitate information and knowledge transfer in the FFE of NPD.***	***Boundary objects** (Henderson, 1991; Carlile, 2002, 2004) ***ICT in information transfer** (Miller et al., 2006; Barczak, et al.,2007, 2008; Haythornwaite, 2002) ***Richness and reach of information** (Daft and Lengel. 1984,1986; Evans and Wurster, 2000; Robert and Dennis, 2005)	**Engineers' drawings are not 100% reliable. In order to reach an acceptable level of drawings' reliability, Suppliers and Engineering need first to negotiate manufacturing trade-offs of all product parts.** **Symptomatic for supplier involvement in product development is that the work of the supplier's Sales Engineer takes the character of a knowledge worker.**

Core Category 2: Supplier Capabilities

Codes (The numbers in brackets indicate the code frequencies).	Core Code	Scope Core Code	Relationship with the Literature	Contribution Thesis
Competitive_advantage (21) **Competitors (31)** **DRAWINGS (39)** **INTERNET (33)** **Manuf_Plant (20)** **Manuf_process_criteria (15)** **Manuf_process_improvements (43)** **Manuf_process_phases (55)** **Manuf_process_product (13)** **Manuf_process_technology (28)** **Manuf_process_trends (13)** **Manufacturing_tooling (21)** **Manufacturing_tools (34)** **Manufacturing_tools_support_software (27)** **Preferred_suppliers (63)** **Preferred_suppliers_definition (21)** **Quality_certification_process (65)** **Quality_certification_process_QPL (12)** **QPL=quality product listing** **Quality_certification_process_tests (42)** *Opinion_negative (176) This is a*	**<u>Supplier Capabilities</u>**	***Supplier capabilities are those areas of supplier information and knowledge that can contribute to the focal firm's FFE of NPD.***	***Supplier involvement/ integration in product development (**Clark, 1989;; Monczka et al., 2000; Croom, 2001; Dowlatshahi 1997, 1998, 2000; Wynstra and Pierick, 2000; Petersen et al., 2003, 2005; Wagner and Hoegl, 2006; van Echtelt et al., 2008; Song and Di Benedetto, 2008; Wynstra et al., 2010). ***Supplier development**	**Some suppliers prefer to see themselves as knowledge providers rather than manufacturers of product components.** **The Supplier Development (SD) is currently focused on improvement of operational capabilities in supplier firms, but SD also has very good potential to become a mechanism for information**

property/dimension code. *Opinion_positive (46) This is a property/dimension code.* **OUTSOURCING (29)** **PROTOTYPES (53)** **R_&_D_supplier (32)** **R_&_D_supplier_incremental (37)** **R_&_D_supplier_motives (51)** *Serendipity (15) This is a property/dimension code.* **Standardization (18)** **Standardization_commitee (18)** **SUPPLIER_AUDITS (24)** **SUPPLIER_DEVELOPMENT (21)** **Supplier_PD_information dissemination (81)** **Suppliers_product_parts_assembly_ time (24)** **Suppliers_product_parts_costs (87)** **Suppliers_product_parts_costs_ standardized (44)** **Suppliers_product_parts_quality (22)** **Suppliers_product_parts_selection (77)** **Suppliers_sales_engineers_contact_frequency (35)** **Suppliers_sales_engineers_contact_quality (41)** **Suppliers_sales_engineers_contacting_ engineers (63)** **Suppliers_sales_engineers_contacting_ purchasing (17)** **Suppliers_sales_engineers_intern_meetings (45) (intern= within the supplier firm)** **Suppliers_sales_engineers_project_facilitator (46)** **TRUST (70)**			(Lamming , 1993; lamming et al., 2005; Krause and Ellram, 1997; Krause et al., 2007; Modi and Mabert, 2007; Wagner and Krause, 2009); ***Sourcing strategies** (Treleven, 1987; Lamming et al., 1996; Swift, 1995; Seshadri, 2005; Van Weele, 2010)	**transfer and knowledge creation between suppliers and customers.**

Core Category 3: Knowledge Creation (Intra-Firm Group Level)

Codes (The numbers in brackets indicate the code frequencies).	Core Code	Scope Core Code	Relationship with the Literature	Contribution Thesis
Business_case (55) This is a property/dimension code **Competitive_advantage (21)** **Competitors (31)** *Core_business (11) This is a property/dimension code.* **DRAWINGS (39)** *Drivers_PD_Competition_driven (7) This a property/dimension code.* *Drivers_PD_Customer_driven (35) This is a property/dimension code.* *Drivers_PD _Market_driven (21) This is a property/dimension code.* *Drivers_PD_Technology_driven (43) This is a property/dimension code* *Feedback (18) This is a property/dimension code.* *Frequency (76) This is a property/dimension code.* **INTERNET (33)**	<u>**Knowledge Creation (Intra-Firm Group Level)**</u>	***Intra-firm knowledge creation is a result of learning resulting from the exchange of information & knowledge between the focal firm's (Design) Engineers & Purchasers in the context of***	***Information transfer & knowledge sharing** (Szulanski, 2002; Cook and Brown, 1999; Davenport and Prusak, 1998; von Krogh et al., 2000; Carlile and Rebentisch, 2003; Carlile, 2004; Cross and Sproull, 2004) ***Knowledge creation and sharing in NPD** (Madhavan and Grover, 1998; Hong et al., 2004; Schulze and Hoegl, 2006)	**The involvement of Purchasing in product development is largely determined by the educational background of the focal firm's Purchasing Manager. When the Purchasing Manager has a technical education the communication between the focal firm's Purchasing and Engineering on one hand, and the supplier firms on the other, is more likely to be**

KNWLS_engineers_customer_firm (4) **KNWLS_engineers_focal_firm-info-dissem (57)** **KNWLS_engineers_focal_firm_meetings (46)** **KNWLS_engineers_supplier_firm (8)** **Manuf_process_improvements (43)** **Manuf_process_lessons_learned (9)** **Manuf_process_phases_trade_studies (43)** *Opinion_negative (176) This is a property/dimension code.* *Opinion_positive (46) This is a property/dimension code.* **Preferred_suppliers (63)** **Preferred_suppliers_definition (21)** **PROTOTYPES (53)** **Quality_certification_process (65)** **Quality_certification_process_tests (42)** **R_&_D_customer (10)** **R_&_D_customer_motives (18)** **R_&_D_focal_firm (38)** **R_&_D_focal_firm_motives (96)** **R_&_D_focal_firm_phases (47)** **R_&_D_financing (51)** **R_&_D_meetings (25)** **R_&_D_supplier (32)** **R_&_D_supplier_incremental (37)** **R_&_D_supplier_motives (51)** *Serendipity (15) This is a property/dimension code.* **SUPPLIER_DEVELOPMENT (21)** **Supplier_integration_in_PD (58)** **Supplier_integration_in_PD_timing (27)** **TRUST (70)**		***the focal firm's FFE of NPD.***	***Knowledge-based theory of the firm** (Nonaka and Takeuchi, 1995; Grant, 1996, 2004; Li and Gao, 2003; Leonard-Barton, 1995; Teece, 2007; Nonaka and Von Krogh, 2009) ***Absorptive capacity** (Cohen and Levinthal, 1990; Nooteboom, 2000; Zahra and George, 2002)	**task-oriented rather than purely cost-oriented.**

Core Category 4: Information Relationship (Intra-Firm Group Level)

Codes (The numbers in brackets indicate the code frequencies).	Core Code	Scope Core Code	Relationship with the Literature	Contribution Thesis
Business_case (55) This is a property/dimension code. **CULTURE (7)** **DRAWINGS (39)** **Engineers_information_behaviour (73)** **Engineers_information_sources_persons (33)** *Engineers_types_of (18) This is a property/dimension code.* *Feedback (18) This is a property/dimension code.* *Frequency (76) This is a property/dimension code.* **INTERNET (33)** **KNWLS_engineers_focal_firm_info_dissem (57)** **KNWLS_engineers_focal_firm_**	**<u>Information Relationship (Intra-Firm Group Level)</u>**	***Intra-firm information relationship is an inter-personal relationship (dyadic or team level) embedded in the exchange of information & knowledge between the focal firm's (Design) Engineers & Purchasers in***	***Tie strength** **(**Granovetter, 1973, 1998; Hansen 1999, Levin and Cross, 2004) ***Social Embeddedness** (Granovetter, 1985; Uzzi 1996. 1997) ***Social capital** (Nahapiet and Ghoshal, 1998; Lin, 2001; Adler and Kwon, 2002; Moran, 2005; Inkpen and	**Exploring the conditions under which the information relationship between the focal firm's Purchasing & Engineering staff operating in the context of the focal firm's product development**

meetings (46) *Location_distance (38) This is a property/dimension code.* **MANAGEMENT DECISION MAKING (34)** **Matrix_organization (8)** **Matrix_organization_problems (9)** *Opinion_negative (176) This is a property/dimension code* *Opinion_positive (46) This is a property/dimension code.* **PERSONNEL_CHANGES (23)** **PROTOTYPES (53)** **RELATIONSHIP_HISTORY (61)** **RELATIONSHIP_TIES (67)** **Relgl_focal_firm_engineering_purchasing (88)** **Relgl_focal_firm_engineering_sales (33)** **RISK_MAMAGEMENT (17)** **SOURCING_COMMITTEE (28)** **Supplier_selection_choice_limitations (46)** **Supplier_selection_criteria (55)** **Supplier_selection_parallel_sourcing (11)** **Supplier_selection_second_source (51)** **Supplier_selection_single_source (61)** **Suppliers_product_parts_selection (77)** **Teams composition (35)** **Teams_formation (42)** **Teams_integrated (30)** *Troubleshooting (12) This is a property/dimension***TRUST (70)**		***the context of the focal firm's FFE of NPD.***	Tsang, 2005) ***Community of Practice** **(**Brown and Duguid, 2001; 2002; Duguid, 2005) ***Sourcing strategies** (Treleven, 1987; Swift, 1995; Seshadri, 2005; Van Weele, 2010)	**can be described as a strong tie, weak tie or a trusted weak tie relationship. Thus, contributing to the theory of tie strength.** **Single sourcing is often a conscious choice (or a consequence) stemming from the focal firms' decision to involve suppliers in the FFE of NPD**

Core Category 5: Knowledge Creation (Inter-Firm Group Level)

Codes (The numbers in brackets indicate the code frequencies).	Core Code	Scope Core Code	Relationship with the Literature	Contribution Thesis
Competitive_advantage (21) **Competitors (31)** *Core_business (11) This is a property/dimension code.* **CULTURE (7)** *Drivers_PD_Competition_driven (7) This a property/dimension code.* *Drivers_Customer_driven (35) This is a property/dimension code.* *Drivers_PD_Market_driven (21) This is a property/dimension code.* *Drivers_Technology_driven (43) This is a property/dimension code.* *Engineers_types_of (18) This is a property/dimension code* **INTERNET (33)** **KNWLS_engineers_customer_focal_firm_tests (29)**	<u>Knowledge Creation (Inter-Firm Group Level)</u>	***Inter-firm knowledge creation is a result of learning resulting from the exchange of information & knowledge between the focal firm's (Design) Engineers & Purchasers, and the Sales Engineers of supplier firms, in the context of joint R&D, or the FFE of NPD.***	***Supplier involvement/ integration in product development** (Clark, 1989; Monczka et al., 2000; Croom, 2001; Dowlatshahi 1997,1998, 2000; Wynstra and Pierick 2000; Petersen et al., 2003, 2005; Wagner and Hoegl, 2006; van Echtelt et al., 2008; Song and Di Benedetto,	**Lack of trust on the part of (Design) Engineers that Suppliers would be willing to engage in commercially independent research.** **The focal firm's Management & (Design) Engineering have an inverse perception of the value that supplier information and supplier**

KNWLS_engineers_customer _suppliers (27) **KNWLS_engineers_customer _suppliers_ meeting (13)** **KNWLS_engineers_focal_firm _customer (44)** **KNWLS_engineers_focal_firm _suppliers (102)** **KNWLS_engineers_focal_firm _suppliers_ meeting (52)** **KNWLS_engineers_focal_firm _suppliers_ tests (52)** *Opinion_negative (176) This is a property/dimension code.* *Opinion_positive (46) This is a property/dimension code.* **Quality_certification_process (65)** **Quality_certification_process _QPL (12) QPL=quality product listing** **R_&_D_financing (51)** **R_&_D_focal_firm_customer (70)** **R_&_D_focal_firm_supplier (103)** **R_&_D_joint_engineering_bureaux (26)** **R_&_D_joint_universities_institutes (37)** **R_&_D_meetings (25)** **R_&_D_supplier_customer (53)** **RELATIONSHIP_TIES (67)** **RISK_MAMAGEMENT (17)** **SUPPLIER_AUDITS (24)** **SUPPLIER_DEVELOPMENT (21)** **SUPPLIER_PARTICIPATION STRATEGY (68)** **Triad_certification_process (4)** **Triad_engineering_design (39)** **Triad_engineering_design_meetings (6)** **Triad_product_parts_selection (21)** **TRUST (70)**			2008; Wynstra et al, 2010) ***Purchasing integration in Product Development** (Burt and Soukup, 1985; Dowlatsahi, 1992; Lakemond et al. (2001; Schiele, 2006, 2010; Wynstra et al., 2000, 2003; van Weele, 2010)	**knowledge can bring to bear on the firm's FFE of NPD.**

Core Category 6: Information Relationships (Inter-Firm Group Level)

Codes (The numbers in brackets indicate the code frequencies).	Core Code	Scope Core Code	Relationship with the Literature	Contribution Thesis
COMMUNICATION_CHANNELS (45) **CULTURE (7)** *Feedback (18) This is a property/dimension code.* *Frequency (76) This is a property/dimension code.* **INTERNET (33)** *Location_distance (38) This*	**<u>Information Relationship (Inter-Firm Group Level)</u>**	***Inter-firm information relationship is an inter-personal relationship (dyadic or team) embedded in the exchange of information & knowledge***	****Open innovation*** (Chesbrough, 2003; Von Hippel,2006) ****Tie strength***	**Exploring the conditions under which the information relationship between the focal firm's Purchasers & (Design)**

is a property/dimension code. **MANAGEMENT DECISION MAKING (34)** *Opinion_negative (176) This is a property/dimension code.* *Opinion_positive (46) This is a property/dimension code.* **Rel_relationships_focal_firm_customer (96)** **Rel_relationships_focal_firm_customer_legal (59)** **Rel_relationships_focal_firm_supplier (66)** **Rel_relationships_focal_firm_supplier_legal (49)** **Rel_relationships_supplier_customer (65)** **Rel_relationships_supplier_customer_legal (20)** **Rel_relationships_supplier_customer_meetings (10)** **RELATIONSHIP_HISTORY (61)** **Relationship_initiative_customer (14)** **Relationship_initiative_engineering_focal_firm (34)** **Relationship_initiative_suppliers (32)** **RELATIONSHIP_TIES (67)** **Relgl_customer_engineering_suppliers (19)** **Relgl_customer_engineering_suppliers_meeting (8)** **Relgl_customer_Engineering_suppliers_visits (8)** **Relgl_customer_purchasing_suppliers (16)** **Relgl_distributors (8) (of suppliers and customers, i.e., not of the focal firm)** **Relgl_focal_firm_engineering_customer (27)** **Relgl_focal_firm_engineering_customer_visits (24)** **Relgl_focal_firm_engineering_suppliers (44)** **Relgl_focal_firm_engineering_suppliers_visits (34)** **Relgl_focal_firm_purchasing_distributors (6)** **Relgl_focal_firm_purchasing_suppliers (59)** **Relgl_focal_firm_purchasing_suppliers_logistics (17)** ***Serendipity (15) This is a property/dimension code.*** **SUPPLIER_PRICE_POLICY (38)** **SUPPLIER_SEGMENTATION_STRATEGY (15)**	***between the focal firm's (Design) Engineers & Purchasers, and the Sales Engineers of supplier firms, in the context of joint R&D, or the FFE of NPD projects.***	(Granovetter, 1973, 1998; Hansen 1999, Rindfleisch and Moorman, 2001; Levin and Cross, 2004; Ganesan et al., 2005) ***Social Embeddedness** (Granovetter, 1985; Uzzi 1996. 1997; McEvily and Marcus, 2005; Lawson et al., 2009)	**Engineers, and the Sales Engineers of supplier firms can be described as a strong tie, weak tie or a trusted weak tie relationship. Thus, contributing to the theory of the Strength of Weak Ties.**

Troubleshooting (12) This is a property/dimension code
TRUST (70)

Core Category 7: Trust

Codes (The numbers in brackets indicate the code frequencies).	Core Code	Scope Core Code	Relationship with the Literature	Contribution Thesis
Trust_ethics (5) **Trust_NPD_confidentiality (13)** **Trust_NPD_cooperation_extern (11)** **Trust_NPD_cooperation_intern (3)** **Trust_NPD_process_control (8)** **Trust_NPD_research (4)** **Trust_past_experience (4)** **Trust_personal_relationships (8)** **Trust_supplier_selection (14)**	**Trust**	**All manifestations and perceptions of trust in the infornation relationships between the focal firm's (Design) Engineers and Purchasers and the Sales Engineers of supplier firms in the context of the FFE of NPD**	***Trust (Theory)** (Mayer, et al., 1995; Schoorman et al. 2007; Perrone et al., 2003; Bachman and Zaheer, 2006) ***Trust in knowledge sharing** (Hertzum, 2002; Abrams et al. 2003; Wang et al., 2006) ***Trust in Product Development** (Jassawalla and Sashittal,1998; Bakker et al., 2006; Bstieler, 2006) **Trust in supplier relationship** (Dwyer et al., 1987; Gulati, 1995; Smeltzer, 1997; Handfield and Bechtel, 2004; Zhang et al., 2011)	**Applying the integrative model of dyadic trust (Mayer et al. , 1995) to the dyadic information relationships found in the four case studies.** **Reconciling the integrative model of dyadic trust (Mayer et al. , 1995)) with the empirical evidence about trusted weak ties.**

Conclusion: The Central Categories

The names that were chosen for the four Central Categories are deliberately more abstract than those of the Core Categories, so as to maintain relatedness among the seven subsumed Core Categories. In creating Central Categories, the researcher was guided by the criteria for choosing a central category developed by Anselm Strauss (cited in Strauss and Corbin, 1998:147).

One of the qualification criteria for creating a central category (i.e., relating and subsuming the earlier made Core Categories) is that the explanation of the Central Category should be logical and consistent. There should be no forcing of data. It is this criterion 'of no forcing of data' that lies behind the decision to subsume in the Central Category Supplier Potential only a selection of codes from the Core Category 5 (Knowledge Creation,Inter- Firm Group Level) and the Core Category 3 (Knowledge Creation,Intra-Firm Group Level). The codes that were subsumed contain the word 'supplier'.

The four Central Categories created are:

- **INFORMATION ENVIRONMENT.** This Central Category subsumes Core Category 1: 'Information transfer facilitators', Core Category 4: 'Information relationships (intra-firm group level), and Core Category 6: 'Information relationships (inter-firm group level)'.
- **SUPPLIER POTENTIAL.** This Central Category subsumes Core Category 1: 'Information transfer facilitators' and Core Category 2:' Supplier capabilities'. Furthermore, the Central Category **SUPPLIER POTENTIAL** also subsumes a selection of codes (codes containing the word "supplier') from Core Category 3: 'Knowledge Creation (intra-firm group level)' and Core Category 5: 'Knowledge creation (inter-firm group level)'.
- **FUNCTIONAL AREA STAFF.** This Central Category subsumes Core Category 3: Knowledge creation (intra-firm group level)', Core Category 4: 'Information relationships' (intra-firm group level)', Core Category 5: 'Knowledge creation (inter-firm group level)' and Core Category 6: 'Information relationships (inter-firm group level).
- **BELIEF.** This Central Category subsumes Core Category 7: 'Trust' and Core
- Category 2: 'Supplier capabilities'.

According to Strauss and Corbin (1998: 146), the test stone for the Central Categories is whether and how they explain what the research is about. Strauss and Corbin (1998) suggest that by using the Central Categories it should be possible to capture the essence of research in just one sentence.
The sentence summing up the research focus of this thesis might run like this:

> *Beliefs about the potential of suppliers are an underlying factor in the information environment in which the functional area staff of supplier and customer firms meet and work together in the FFE of NPD projects.*

Appendix 5: Profiles of Participants Firms

PROFILES	A	B	C	D
Year of foundation	1961	1935	1925	1922
Core business	Electrical distribution systems	Automotive mirror industry	Automation technology	Naval radar and communication systems
Turnover in the year 2011	150M€	Confidential	2.100M€ (Group of 59 independent companies)	600M€
Number of employees	1.700	>500	15.500	2.000
Number of customers	20 aerospace customers including major aircraft manufacturers	>10	300.000 in 176 countries	75-100
Number of suppliers	180 worldwide (of which 20 are the so-called preferred suppliers)	70 worldwide (of which 10 represent the suppliers of preferred technologies)	700	1100 (of which 10% account for 80% of purchase volume)

summary

Research Aims and Research Questions

In today's world of multi-component and multi-technology products, firms are obliged to seek knowledge for new product development (NPD) from external sources. Supplier firms are one such external source.

The present thesis aims to contribute to the development of a theory on supplier involvement in new product development (NPD) by advancing understanding of the motives and conditions for the utilization of supplier information and knowledge in the fuzzy front end (FFE) of NPD.

The term 'fuzzy front end' (FFE) refers to the activities that the firm undertakes prior to a NPD project. The FFE ends when the NPD project is launched, or rejected. The FFE of NPD is information intensive: it requires seeking, accessing and selecting different types of information from both internal and external sources. Previous research focused mostly on the external source of consumers and how ideas from consumers can lead to the generation of new product concepts. By comparison, the suppliers' contribution to the FFE of NPD has received less attention.

The first empirical study on supplier involvement in the FFE of NPD was published only recently (Wagner, 2012). This is surprising given the fact that the earliest research on supplier involvement in NPD dates back to 1980's. At first the focus was on the automotive industry in Japan. Later, the research was extended to other countries and other industries. The literature review in Chapter 2 outlines the growing interest in supplier involvement in NPD in relation to the new product market performance.

The present thesis has a different objective in that it investigates supplier involvement in the FFE of NPD from the perspective of the use and non-use of supplier information and knowledge. The thesis examines the exchange and utilization of supplier information and knowledge at the micro-social level of the firm between the individuals who work in the FFE of NPD. Three functional areas have been selected for the study, namely: (Design) Engineering and Purchasing of the customer firm and Sales Engineering of the supplier firm.

As the (Design) Engineers, Purchasers and Sales Engineers exchange supplier information and knowledge with one another, they form pairs, or dyads, in which the (Design) Engineers and Purchasers are the users, and the Sales Engineers are the providers of supplier information and knowledge.

The Conceptual Framework (Figure 3.3 in Chapter 3) illustrates the possible dyad configurations. The supposition behind the Conceptual Framework is that the utilization of supplier information and knowledge in the FFE of NPD is an outcome of a dyadic information relationship between the user and the provider, and that the information relationships are enabled by tie modality
(i.e., the type of social tie that exists between the exchanging parties).
The Conceptual Framework draws on the theory of "The Strength of Weak Ties" (Granovetter, 1973, 1982; Levin and Cross, 2004), when it conjectures that the type of social tie (e.g., strong tie, weak tie, and trusted weak tie) influences whether or not the exchanged supplier information and knowledge will be utilized. The thesis seeks answers to the following Research Questions:

RQ1: What does constitute an information relationship between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of supplier and customer firms during the fuzzy front end (FFE) of new product development (NPD)? What type of information and knowledge is exchanged?

RQ2: How does an information relationship between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of supplier and customer firms work? How does the exchange of information and knowledge take place?

RQ3: Why do some information relationships between the individuals in the functions of (Design) Engineering, Purchasing and Sales Engineering of supplier and customer firms lead to the utilization of supplier information and knowledge, and other do not?

Structure and findings of the thesis

The research design of the thesis is a multiple case study involving four firms. The structure consists of four Within-case Analyses and a Cross-case Analysis.
The Within-case Analyses (Chapters 4-7) follow an uniform pattern and analyse the firms in two steps. Step 1 briefly describes the external information relationships of the firm under study. Step 2 examines the information relationships of the firm at the micro-social level. It analyses the interpersonal dyadic information relationships between (Design) Engineers, Purchasers, and Sales Engineers. The analysis is guided by the Research Questions, and focuses on the What's, the How's, and the Why's/Why not's of these dyadic information relationships. A tabular display at the end of the chapter summarizes the findings.
The Within-case Analyses of the dyadic information relationships in the four firms resulted in the identification of 22 Salient Issues (Table 8.1 in Chapter 8), drawn from the researcher's Reflective Comments about the found case evidence. The Salient issues and the accompanying Reflective Comments can be found in text-boxes throughout the Within-case Analyses. In turn, the Salient Issues served as input for the Cross-case Analysis in Chapter 8.

The Cross-case Analysis (Chapter 8) identified and investigated four Multicase Themes that characterized the information relationships in the FFE of NPD across the four firms. The Multicase Themes were: Social Ties, Single Sourcing, Boundary Objects, and Trust.

The Cross-case Analysis examined the credibility of the Multicase Themes by analysing the Multicase Themes against the background of primary scholarly work (Section 8.3). Next, the Cross-case Analysis validated the Research Questions using the Multicase Themes and the underlying Salient Issues (Section 8.4). The Cross-case Analysis further resulted in the formulation of the Cross-case Assertions about the Multicase Themes (Section 8.5). Lastly, the Cross-case Analysis examined the Multicase Theme in relation to the Conceptual Framework (Section 8.6), which resulted in a modification of the Conceptual Framework shown in Figure 8.4.

The modification related to the framework's construct of the utilization of supplier information and knowledge. The Conceptual Framework in Figure 3.3 in Chapter 3 conjectured that the exchange of supplier information and knowledge would automatically result in the utilization of that supplier information and knowledge. However, the case evidence drawn from the analysis of the Multicase Theme of Trust (Section 8.3.4, Box 8.4), and mirrored in the Cross-case Assertion about the Multicase Theme of 'Physical (Boundary) Objects' (Section 8.5.3) indicated that the utilization of supplier information was not an instant action, but a process consisting of two phases: adoption and implementation. Moreover, the evidence revealed that the two phases were not temporally linked: there was no time-ordered sequence. The adoption phase was found to be a separate process from that of implementation, thus confirming the time-gap identified by Rogers (1983) in his theory of Innovation Diffusion. In modifying the construct of the utilization of supplier information and knowledge, the concept of 'actionable knowledge' (Cross and Sproull, 2004), identified in the literature review (Chapter 2, Section 2.4.3), has proved useful because it combines knowledge utilization and dyadic interpersonal social relationships.

Conclusions

The contribution of the final Conceptual Framework (Figure 8.4) to the development of theory on supplier involvement in new product development (NPD) is fourfold.

Firstly, the Conceptual Framework concentrates on the less researched field of the FFE of NPD and the potential benefit of supplier information and knowledge therein;

Secondly, the Conceptual Framework presents the customer/supplier interaction during the FFE of NPD as a dyadic information relationship between the functional areas at the micro-social level of the customer and supplier firm;

Thirdly, the Conceptual Framework links the utilization of supplier information and knowledge in the FFE of NPD to the theory of Innovation Diffusion (Rogers, 1983) by highlighting the time gap between the adoption and implementation of supplier information and knowledge; and

Fourthly, and perhaps most importantly, the Conceptual Framework draws on the research on social ties and how social relationships facilitate and affect the exchange and utilization of information and knowledge (Cross and Sproull, 2004; Granovetter, 1973, 1982; Hansen, 1999; Levin and Cross, 2004). In consequence, the Conceptual Framework presents the utilization of supplier information and knowledge in the FFE of NPD from a relational perspective.

Future research could focus on how to measure the utilization of supplier information in the FFE of NPD. The present thesis has identified two objects of measurement (Dul and Hak, 2008), both of which are directly related to the utilization of supplier information and knowledge, and would therefore allow to extract evidence about the value of the utilization of supplier information and knowledge. The two objects of measurement are the Multicase Themes of Physical (Boundary) Objects and Single Sourcing. Thus, by measuring, for example, the frequency with which the Physical (Boundary) Objects were used in the FFE of NPD, or the frequency with which the customer firm engaged in Single Sourcing, would give an indication about the value of the utilization of supplier information and knowledge to the customer firm.

Managerial implications

The first managerial implication of the thesis' findings is that firms need to acknowledge supplier firms as a knowledge source, and not only as a trading partner. The evidence from the four case studies suggests that such increased awareness of supplier knowledge is more likely to arise as a result of a bottom-up process, with (Design) Engineers taking the lead. The (Design) Engineers have frequent hands-on exchange of knowledge with the suppliers' Sales Engineers and, therefore, are in a better position to appreciate the benefits of supplier information and knowledge than the NPD Managers, who have a tendency to downplay the potential contribution of suppliers' knowledge to the FFE of NPD.

The second managerial implication is that the deployment of social ties to access and disseminate knowledge, both within the firm and across the firm's boundaries, offers a complementary approach to managing customer/supplier relationships. The case evidence shows that exchanging expertise with another party takes time and mutual trust. Therefore, Management should empower and award the employees for investing time and effort to build social ties with their counterparts in supplier firms. Management should be aware that having a solid social network represents a new type of capability that is difficult to replicate and can therefore become a source of competitive advantage.

samenvatting

Onderzoeksdoelstelling en onderzoeksvragen

Vandaag de dag bestaan producten uit meerdere componenten en meerdere technologieën en bedrijven zijn derhalve genoodzaakt om kennis t.b.v. productontwikkeling ook bij externe bronnen, d.w.z. buiten het bedrijf, te zoeken. De leveranciers zijn één van de externe kennisbronnen.

Het proefschrift verschaft inzicht in de motieven en voorwaarden voor het gebruik van leveranciersinformatie en kennis tijdens de 'fuzzy front end' (FFE) van de productontwikkeling.

Het begrip 'fuzzy front end' (FFE) verwijst naar de activiteiten die het bedrijf verricht voordat het productontwikkeling project van start gaat. De periode van de FFE wordt beëindigd met het starten van een project, of met het afwijzen ervan.

De werkzaamheden tijdens de FFE kenmerken zich door intensief informatiegebruik: men is bezig met het zoeken en selecteren van informatie, zowel binnen als buiten het bedrijf.

Eerder onderzoek heeft zich vooral gericht op de consumenten als een externe bron, en hoe de ideeën van consumenten kunnen leiden tot het bedenken van nieuwe productconcepten. Hierbij vergeleken, is de aandacht voor de leveranciers als een externe informatiebron bij de FFE gering geweest.

De eerste empirische studie die ging specifiek over de participatie van leveranciers in de FFE van productontwikkeling is pas recent verschenen (Wagner, 2012). Dit is merkwaardig gezien het feit dat het onderzoek naar de participatie van leveranciers in productontwikkeling reeds in de jaren 1980 is begonnen. Aanvankelijk was het onderzoek gericht op de auto-industrie industrie in Japan. Later volgden de studies in andere landen en industrieën. Het literatuuronderzoek in hoofdstuk 2 laat de groeiende belangstelling zien voor het onderzoek over de participatie van leveranciers bij productontwikkeling in relatie tot het marktsucces van nieuwe producten.

Dit proefschrift streeft een ander doel na, namelijk: het bestuderen van de participatie van leveranciers in de FFE van productontwikkeling vanuit de optiek van het wel of niet gebruiken van de informatie en kennis van de leveranciers. Het proefschrift onderzoekt de uitwisseling van informatie en kennis op het micro-sociaal niveau van het bedrijf tussen de personen die in de FFE van productontwikkeling werken. Er worden drie functies onderzocht, t.w.: ontwerpingenieurs en inkopers van het klantbedrijf en de verkoopingenieurs van het leveranciersbedrijf.

Wanneer de ontwerpingenieur, de inkoper en de verkoopingenieur de leveranciersinformatie en kennis bespreken of uitwisselen, doen ze dat in tweetallen oftewel dyaden. Hierbij zijn de ontwerpingenieurs en inkopers de gebruikers, terwijl de verkoopingenieurs de verschaffers zijn van leveranciersinformatie en kennis. Het conceptueel raamwerk (Figure 3.3 in hoofdstuk 3) geeft de mogelijke dyadische configuraties aan. De achtergrondgedachte van het conceptueel raamwerk is dat het wel of niet gebruiken van de leveranciersinformatie en kennis de uitkomst is van een dyadische informatierelatie tussen de gebruiker en de verschaffer, en dat deze informatierelatie mogelijk wordt gemaakt door het type sociale band ('social tie') tussen de twee partijen.

Het conceptueel raamwerk is afgeleid van de theorie van "The Stregth of Weak Ties'(Granovetter, 1973, 1982; Levin en Cross, 2004). Het raamwerk beschrijft hoe het wel of niet gebruiken van leveranciersinformatie en kennis wordt beïnvloed door het type sociale relatie (in de vorm van 'strong ties', 'weak ties' en 'trusted weak ties'.).

Het proefschrift zoekt antwoorden op de volgende onderzoeksvragen (OV):

OV1: Waarop stoelt de informatierelatie tussen de personen werkend in de functies van ontwerpingenieur, inkoper en de verkoopingenieur in een klantbedrijf en leveranciersbedrijf tijdens de FFE van productontwikkeling? Welke informatie en kennis worden uitgewisseld?

OV2: Hoe functioneren de informatierelaties tussen de personen werkend in de functies van ontwerpingenieur, inkoper en verkoopingenieur van een klantbedrijf en leveranciersbedrijf? Hoe komt de uitwisseling van informatie en kennis tot stand?

OV3: Waarom resulteren sommige informatierelaties tussen de personen werkend in de functies van ontwerpingenieur, inkoper en verkoopingenieur van een klantbedrijf en een leveranciersbedrijf wel in het gebruik van leveranciersinformatie en kennis, terwijl andere informatierelaties dat resultaat niet halen?

Structuur en bevindingen van het proefschrift

De onderzoeksmethode is een vergelijkende gevalstudie (case study) waaraan vier bedrijven meewerkten. De structuur bestaat uit vier interne ('within-case') analyses en een vergelijkende ('cross-case') analyse.

De interne case analyses (hoofdstukken 4-7) hebben een gelijke structuur: de analyse verloopt in twee stappen. Stap 1 geeft een korte blik op de externe informatierelaties van het bedrijf. In Stap 2 ligt de focus op de interpersoonlijke dyadische informatierelaties tussen ontwerpingenieurs, inkopers en verkoopingenieurs. De analyse is gericht op de onderzoeksvragen omtrent het wat, hoe, en waarom/(waarom niet) van de onderzochte dyadische informatierelaties. Een overzichtstabel aan het eind van elk hoofdstuk geeft een samenvatting van de bevindingen.

De interne analyse van de vier bedrijven heeft geresulteerd in het identificeren van 22 opvallende kenmerken of omstandigheden ('salient issues') van de dyadische informatierelaties (tabel 8.1 in hoofdstuk 8).

De opvallende kenmerken zijn ontleend aan de reflectieve overwegingen ('reflective comments') van de onderzoeker. De 'salient issues' met de bijbehorende 'reflective comments' zijn te vinden in tekst boxen. De 'salient issues' vormen de input voor de vergelijkende ('cross-case') analyse in hoofdstuk 8.
De vergelijkende ('cross-case') analyse in hoofdstuk 8 identificeerde vier thema's ('Multicase Themes') die voor de bedrijven gemeenschappelijk waren, namelijk: 'social ties', 'single sourcing', 'boundary objects' en 'trust'.
De vergelijkende analyse is gericht op de geloofwaardigheid van de vier thema's door elk thema te bespreken in de context van de wetenschappelijke literatuur op het betreffende vakgebied (sectie 8.3). De volgende stap in de vergelijkende analyse was het valideren van de onderzoeksvragen met behulp van de vier thema's en de 'salient issues' (sectie 8.4). De vergelijkende analyse heeft verder geresulteerd in het formuleren van uitspraken ('cross-case asssertions') over de vier thema's (sectie 8.5). De vergelijkende analyse vergeleek tenslotte de thema's in relatie tot het conceptueel raamwerk (sectie 8.6). Dit resulteerde in een aanpassing van het conceptueel raamwerk (Figure 8.4).
Dit raamwerk had betrekking op de concept van het wel of niet gebruiken van de leveranciersinformatie en kennis. Het conceptueel raamwerk in Figure 3.3 (hoofdstuk 3) poneert dat de uitwisseling van informatie en kennis automatisch zal resulteren in het gebruik ervan. Echter, de bevindingen van de analyse van het thema 'trust' (sectie 8.3.4, box 8.4) en ook de bevindingen weerspiegeld in de uitspraak ('cross-case assertion') m.b.t. het thema 'physical (boundary) objects' hebben laten zien dat het gebruik van leveranciersinformatie en kennis geen eenmalige actie is die per direct geschiedt, maar dat het een proces betreft welk bestaat uit twee fasen, t.w. adoptie en implementatie.
De bevindingen tonen bovendien aan dat de twee fasen niet het hetzelfde tijdpad volgen; er is geen vastgelegde tijdsvolgorde. De 'time-gap' tussen adoptie en implementatie die al eerder door Rogers (1983) in zijn theorie "Innovation Diffusion" is beschreven, vindt in dit proefschrift een bevestiging.
Bij het aanpassen van het conceptueel raamwerk is gebruik gemaakt van het concept 'actionable knowledge' (Cross en Sproull, 2004), gevonden door het literatuuronderzoek (hoofdstuk 2, sectie 2.4.3). Het concept is nuttig en bruikbaar omdat het gebruik van informatie en kennis met de dyadische interpersoonlijke relaties combineert.

Conclusie

De bijdrage van het conceptueel raamwerk in Figure 8.4 tot het ontwikkelen van de theorie over de participatie van leveranciers bij productontwikkeling heeft vier aspecten:

1. Het conceptueel raamwerk bevat de voordelen van het gebruik van leveranciersinformatie en kennis in de FFE van productontwikkeling. Het is een weinig onderzocht gebied;
2. Het conceptueel raamwerk presenteert de interactie tussen klanten en leveranciers als een dyadische informatierelatie tussen de functies op het micro-sociaal niveau van het klantbedrijf en het leveranciersbedrijf;
3. Het conceptueel raamwerk verbindt het gebruik van leveranciersinformatie en kennis met de theorie van Innovation Diffusion (Rogers, 1983) door te onderstrepen de 'time-gap' tussen adoptie en implementatie van leveranciersinformatie en kennis in de FFE van productontwikkeling;
4. Het conceptueel raamwerk is afgeleid van het onderzoek over sociale relaties en hoe de sociale banden het gebruik van informatie en kennis vergemakkelijken en beïnvloeden (Cross en Sproull, 2004; Granovetter, 1973, 1982; Hansen 1999; Levin en Cross, 2004). Met als resultaat dat het conceptueel raamwerk het gebruik van de leveranciersinformatie en kennis in de FFE van productontwikkeling in een relationeel perspectief plaatst.

Toekomstig onderzoek kan zich richten op het meten van het gebruik van leveranciersinformatie en kennis in de FFE van productontwikkeling. Dit proefschrift heeft twee meetbare objecten geïdentificeerd die als 'objects of measurement'(Dul en Hak, 2008) dienen en informatie kunnen verschaffen over het gebruik van leveranciersinformatie en kennis omdat ze daar direct aan zijn gerelateerd. De twee meetbare objecten zijn de thema's 'physical (boundary) objects' en 'single sourcing'. Het meten van de frequentie waarmee de physical (boundary) objects worden gebruikt, of de frequentie waarmee het klantbedrijf de inkoop tactiek van 'single sourcing' toepast, levert gegevens op over de waarde die het klantbedrijf aan de leveranciersinformatie en kennis toekent.

Implicaties voor het management

Bedrijven kunnen de leveranciers meer als een kennisbron dan alleen als een handelspartner beschouwen. De bevindingen van de vier case studies tonen aan dat zulk een bewustwordingsproces met betrekking tot de waarde van leveranciersinformatie en kennis naar waarschijnlijkheid een bottom-up proces is, met ontwerpingenieurs in de voortrekkersrol. De ontwerpingenieurs komen vaker in aanraking met de verkoopingenieurs en hebben derhalve hands-on ervaring met het uitwisselen van informatie en kennis. De ontwerpingenieurs zijn daarom beter in staat om de voordelen van de leveranciersinformatie en kennis te waarderen dan productontwikkelingsmanagers die de neiging hebben om de bijdrage van leverancierskennis aan de FFE van productontwikkeling te bagatelliseren.

De tweede management implicatie is dat het inzetten van sociale banden voor het distribueren en aanschaffen van informatie en kennis zowel binnen als buiten het bedrijf een aanvullende aanpak op de normale klant/leverancier relatie biedt. Het onderzoek toont aan dat het uitwisselen van informatie en kennis vereist tijd en wederzijds vertrouwen.

De productontwikkelingsmanagers zouden de werknemers moeten bijstaan in het creëren van sociale banden met de leveranciersbedrijven en het onderhouden van dergelijke sociale banden ook belonen. Het management zou zich moeten realiseren dat een gedegen sociaal netwerk een nieuwe bron van een concurrentie voordeel vertegenwoordigt dat uniek is omdat het moeilijk te imiteren is.

about the author

Jarmila Kopecká has worked in the Department of Product Innovation Management of the Faculty of Industrial Design Engineering since 1981. Over the years, she acted as mentor and tutor in the courses on Research in Design, Literature Research and Review, Strategic Product Innovation, Minor Industrial Design (Design Histories) and graduation projects. As shown in the publications list below, Jarmila's main research interests are information seeking behaviour of (Design) Engineers and knowledge transfer during product development, and in particular, the role of supplier firms therein. She has co-authored book chapters and articles in journals, such as *International Journal of Design*, *Journal of Business Research*, *Journal of Enterprise Management*, and *Environmental Engineering and Management Journal*. She also co-authored and presented papers at the conferences of EIASM (European Institute for Advanced Studies in Management), IPDMC (International Product Development Management Conference), IPSERA (International Purchasing and Supply Education and Research Association) and the IMP Group (International Marketing and Purchasing Group).
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