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Sari Uusipaavalniemi

FRAMEWORK FOR ANALYSING AND DEVELOPING INFORMATION INTEGRATION

A STUDY ON STEEL INDUSTRY MAINTENANCE SERVICE SUPPLY CHAIN

FACULTY OF TECHNOLOGY,
DEPARTMENT OF INDUSTRIAL ENGINEERING AND MANAGEMENT,
UNIVERSITY OF OULU

ACTA UNIVERSITATIS OULUENSIS
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SARI UUSIPAAVALNIEMI

FRAMEWORK FOR ANALYSING AND DEVELOPING INFORMATION INTEGRATION

A study on steel industry maintenance service supply chain

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Supervised by
Professor Harri Haapasalo

Reviewed by
Professor David B. Grant
Professor Karen Spens

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Faculty of Technology, Department of Industrial Engineering and Management, University of Oulu, P.O.Box 4610, FI-90014 University of Oulu, Finland
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Abstract

Information integration – sharing of pertinent information between supply chain members – is vital to cope with the uncertainty and complexity embedded in service supply chains. The aim of this study is to understand the meaning, constituents, extent, and development means of information integration in service supply chain context. The research approach is abductive, emphasising the constant interplay between theory development and empirical observations. Analysis on a single case supply chain consisting of two types of maintenance service providers and a large steel manufacturer as the focal company is provided.

A comprehensive conceptual framework for analysing and developing information integration in service supply chain is presented and applied in the case supply chain. Extent of integration is described through three levels of integration. Six information integration elements are used to define the levels: processes and activities, information technology use, information attributes, information sharing practices, collaborative foundation, and time-related issues. Service/market characteristics and supply chain relationship characteristics are deployed in explaining the differences in levels of integration. Depending on the level of integration, the performance effects sought and achieved through developing information integration range from operational to strategic level. Adopting a more structured approach to information integration in the case supply chain is suggested to address development areas in information sharing and improve performance. This can be implemented through a shared centralised maintenance information system, common procedures for information sharing, and commitment of supply chain actors.

The framework in this study offers guidelines for choosing the appropriate level of integration in a service supply chain dyad. It shows that the special characteristics of service context can be deployed in designing and managing service supply chains. Service providers should be integrated to the supply chain just like other supply chain members, as it contributes to the supply chain performance. Differentiating the level of integration in service supply chain dyads within a supply chain based on the contextual setting is recommended. This study paves the way for better understanding and control of service supply chain links and contributes to the scarce empirical research on service supply chains.

Keywords: information integration, information sharing, maintenance process, service supply chain, supply chain integration, supply chain management

To my aunt Kaarina

Acknowledgements

When I opened the door to University of Oulu first time in autumn 1995 as a candidate for matriculation examination in order to become acquainted with the study opportunities it provides, little did I know about what I would become and do in the future 'when I will grow up'. Years have passed and I am about to complete my doctoral studies.

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As I am now writing the last few lines of my doctoral thesis, I go back to that first day at the University of Oulu and think what I have in common with that young woman I then was. I realise it is still impossible for me to know exactly what I will be and do in the future and I still have not quite ‘grown up’ (perhaps I do not even want to….)! But I know what I *can* do and what I *can* be. And with the same curiosity and courage I had back then, I am excited to pick out the next enticing door, open it, and see where it leads me.

Oulu, June 2009 Sari Uusipaavalniemi

Abbreviations

EDI	Electronic Data Interchange
EO	Engineering office (in this study)
ERP	Enterprise Resource Planning
FC	Focal company (in this study)
FMEA	Failure Mode and Effect Analysis
IS	Information system
IT	Information technology
MM	Mechanical maintenance service provider (in this study)
QFD	Quality Function Deployment
RFID	Radio Frequency IDentification
RQ	Research question
SCI	Supply Chain Integration
SCM	Supply Chain Management
SEBI	Semantic business interoperability (a research project in this study)
SME	Small or medium-sized enterprise
TBM	Time-Based Management
VMI	Vendor-managed inventory

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1 Introduction

1.1 Background

The concept of supply chain management (SCM) is based on integration. Integration in SCM research is commonly defined as collaboration and coordination (e.g. Krajewski & Wei 2001) or collaboration and interaction (e.g. Kahn & McDonough 1997, Ellinger *et al.* 2000). Some see integration as a synonym to collaboration (e.g. Mintzberg *et al.* 1996). The scope of integration studied has varied from integration within a function (e.g. Ellinger *et al.* 1997) to integration between functions (typically functional dyads) (e.g. Kahn & McDonough 1997, Wheelwright & Clark 1992) and integration between organisations (e.g. Krajewski & Wei 2001, Frohlich & Westbrook 2001, Narasimhan & Kim 2001). Main drivers for integration are the information revolution, increased global competition and emergence of new types of inter-organisational relationships (Handfield & Nichols 1999).

Integration in supply chain is a complex process and requires consistent involvement of both (or all) parties in it (e.g. Cousins & Menguc 2006). To date supply chain integration has been studied as a very limited concept and there is a need for more comprehensive theoretical frameworks in integration research in general (e.g. van Donk & van der Vaart 2005b, Fabbe-Costes & Jahre 2007, Fabbe-Costes & Jahre 2008). Likewise, the operationalisations of the construct of integration in research so far vary remarkably. Moreover, majority of the supply chain integration research focuses on describing the relationship between integration and performance, not on setting ways to achieve the integration (Pagell 2004). Several researchers have demonstrated a lack of integration in real-life supply chains (e.g. Fawcett & Magnan 2002, Bagchi *et al.* 2005). Pagell (2004) suggests that one reason for the lack of integration is the lack of knowledge on how to achieve integration in practice. Establishing guidelines for implementing integration is, however, challenging, as many of the constructs enabling and inhibiting integration are interrelated and creating integration is thus complex (see e.g. Pagell 2004).

Thus, there is a clear need for a more holistic view of integration and well-grounded integration constructs. The impact of context to the extent of integration has often been neglected in the earlier studies, although, for instance, business conditions undoubtedly affect the extent of integrative activities in a network (e.g.

van Donk & van der Vaart 2005b). The integration efforts in a supply chain are generally directed towards the links between manufacturers and customers (also retailers) or - most commonly - between manufacturers and suppliers. Yet, there is the nearly untapped potential for realising the full benefits of information integration also in the links between manufacturers and their service providers (see e.g. Mortensen & Lemoine 2008). As business-to-business services are a growing industry field and companies increasingly outsource their operations (such as maintenance, logistics, etc.) to external service providers, it becomes more and more important to be able to understand and manage the service supply chains. In service supply chains, there is often no material flow involved, so the focus should be laid on managing and integrating the flow of information.

In studies dealing with integration, information sharing is unanimously seen as an essential aspect, or even the foundation of supply chain integration (e.g. Sahin & Robinson 2005, Goffin *et al.* 2006). The competitive value of information is widely proclaimed: information substitutes for inventory, shortens order fulfilment cycles, speeds up new product and service design, facilitates process redesign, and helps to coordinate supply chain activities (see e.g. Cachon & Fisher 2000, Kulp *et al.* 2004, Lee *et al.* 2000). It is also well known that the value of information does not come from the information itself, but from its use (Alter 1999). Information provides the visibility needed to make decisions that improve supply chain performance (Chopra & Meindl 2001). Information is also used as power to build relationships with other organisations and to advance organisations' own interests (Williams & Moore 2007). Yet inefficient flow of information causes problems in supply chains, such as the bullwhip effect (demand amplification in chain), inflexibility and incapability to respond to sudden changes, excessive costs, and long lead times for products or services. Up till now, most of the research concerning information sharing in supply chains is related to inventory, forecasting, orders and production plans (e.g. Lee & Whang 2000). Yet there is also other critical information to be exchanged between the supply chain members that have gained less attention in supply chain research so far. Hence, the SCM research should be diversified to cover new types of supply chain information shared.

Research focusing on information sharing (or integration) has been criticised for assuming only a limited perspective to information sharing. Indeed, so far most of the managerial and theoretical focus in information sharing has been on the technological side of information sharing capability. This leads to a situation where the technology is in place, but neither the structure nor the culture to share

information is established. (Fawcett *et al.* 2007). A more holistic approach to information integration specifically is needed. It has been suggested that further integration research should build more on earlier research to obtain improved measures for integration and supply chain performance (e.g. Fabbe-Costes & Jahre 2007). Above all, if information integration is seen as a synonym to information sharing (as e.g. in Lee & Whang 2001), it should be ensured that the information sharing is viewed as an entity covering the essence of integration, i.e. the collaboration, coordination and interaction aspects.

One aspect to be considered is, whether the special characteristics of a supply chain affect the pursuit of integration. More research is needed concerning whether the benefits of information sharing are higher for certain types of products (or services) or businesses (for instance newly launched products, products with high demand uncertainty, etc.) (e.g. Lehtonen *et al.* 2005). Also Bagchi & Skjoett-Larsen (2002) recognise the need for examining the differences in supply chain integration between various industries. Furthermore, a more differentiated approach to integration has been suggested for instance by Fabbe-Costes & Jahre (2007) and Bask & Juga (2001). Through this, the traditional mantra 'the more integration, the better' has been questioned in SCM research.

The demand for services as an input to the production of goods has grown continually and the distinction between goods and services has become more difficult to make (Bryson *et al.* 2004). Service sector is the largest and fastest-growing sector of economies in many developed countries (Chase & Apte 2007). Today even major manufacturing companies generate a remarkable portion of their revenues from services. The increased complexity and power of modern information technology create new challenges in managing services (e.g. Chase & Apte 2007). Despite all this, according to Machuca *et al.* (2007) the amount of service operations management research has still only been minimal. The research in service operations has focused on applying industrial management concepts on services, developing frameworks for service design and management, and identifying tools and techniques for improving productivity in service operations. Some examples of the research themes dealing with services are developing a framework for new service development, constructing a service quality model, identifying unique service characteristics and developing a service classification. The focus has been mostly on services targeted at consumers, and business-to-business services have received less attention in service-related research. (Chase & Apte 2007, Heineke & Davis 2007). Services have only recently gained more attention in the operations management and SCM research and research

concerning services is still in its infancy stage. There are missed opportunities for improved management and control of service supply chains and a lack of information technology and resources to support purchasing and management of services (Ellram *et al.* 2007). First step in responding to these challenges could be taken by paying attention to the information flows related to services. Managing information flow is especially important in business-to-business services, which often need to be customised to meet the customer's needs (e.g. Fitzsimmons *et al.* 1998), thus adding to the uncertainty and complexity embedded in them.

1.2 Research problem and motivation

As illustrated in the description of the background, the main motivation for this research stems from the obvious need to assimilate a more holistic and theoretically well-founded approach to describe and analyse information integration in supply chain. Based on this, the problem statement in this study is:

> *There are no clear guidelines telling why to integrate information, what information to integrate and how far and deep in the supply chain the integration should be extended.*

Moreover, implementation of information integration embodies many stumbling stones and requires time and resources. Thus it should be carefully considered, where the limit in integration should be drawn and under which conditions integration is advantageous.

To capture the complex nature of the construct of information integration, its dimensions need to be defined. A comprehensive set of theoretically sound concepts needs to be selected to be able to describe the state or extent of integration in a real-life supply chain context. The link between the extent of information integration and the context where integration is pursued needs to be defined and explored. The need to pay attention to the contextual factors affecting integration has already been recognised but not yet widely operationalised in the supply chain research (e.g. van Donk & van der Vaart 2005b). Finally, there is a need to address the interrelation between integration and its desired outcome, improved supply chain performance. Although the benefits and improvements in performance brought by supply chain integration, information sharing as its foundation, have already indisputably been shown in some supply chains, it still seems that few companies have fully exploited information's ability to enhance supply chain performance. Consequently, new ways should be figured out to

define and strengthen the link between information integration and supply chain performance. The emphasis of this study is on ways to achieve integration and its performance effects in practice in a specific supply chain context, rather than specifying general links between individual performance effects and dimensions of integration.

The service focus of this study attests to the recently awakened interest in service supply chains among SCM researchers but also addresses a clear gap in SCM and integration research. The integration efforts in supply chains are generally directed towards the links between manufacturers and customers or - most commonly - between manufacturers and suppliers. According to Ellram *et al.* (2004), services have largely been ignored in supply chain research. The need for more research concerning service supply chain practices has also been highlighted by Sengupta *et al.* (2006) and Closs & Savitskie (2003). The service outsourcing is growing very rapidly (e.g. Allen & Chandrashekar 2000), and thus the need to understand and manage the services spent and the service supply chain will gain more importance in the future (Ellram *et al.* 2004). Services are an information intensive business field and increasingly involved also in manufacturing supply chains. Business-to-business services especially are a growing industry field, and even traditional manufacturers are developing additional services to support their products and bring more profits (a phenomenon called *servitisation*). Thus, there is an obvious need to explore the service operations and service supply chain practices more thoroughly. This study will be helpful in identifying and understanding the information integration needs, possibilities and capabilities in a service-oriented supply chain environment, which is vital for future success and competitiveness of supply chains.

This study has steel industry as the empirical research environment. There are some recent dissertations dealing with steel industry in Finland. Salo (2006) examined business relationship digitalisation in steel industry from the theoretical perspective of business marketing. Iskanius (2006) has been modelling information flows in project-based deliveries from the perspective of agility in supply chain. Helaakoski (2007) has examined technology in information sharing and networking. However, these earlier studies have not adequately covered the integration of service providers and information related to services in steel industry supply chains, which leaves a gap to fill with this piece of research.

Beyond the comprehensive approach to information integration this research is characterised by two intentions: To address the disputed, but yet quite unexplored notion of *differentiation* in integration (advocated by Fabbe-Costes &

Jahre 2007, Bask & Juga 2001), and also to get closer to the challenge of *creating guidelines or rules for integration* in supply chains. This research on supply chain information integration in service context adds a new dimension to the empirical research knowledge and thus in the future facilitates the comparison and identification of special characteristics and integration needs of not only different industries, but of different supply chains and supply chain dyads on a more detailed level.

1.3 Research purpose/objectives

The main objective of the study is to understand the meaning, extent and constituents of information integration in steel industry maintenance service supply chain and define ways to facilitate information integration and its performance effects in the supply chain.

The main objective can be further divided into three research questions:

1. What are the important elements and the meaning of information integration in steel industry maintenance service supply chain?
   a) What elements are included in information integration in the literature and how its importance is explained in service supply chain?
   b) What elements of information integration are important in the case supply chain?
2. What factors affect the extent of information integration in steel industry maintenance service supply chain?
   a) How is the extent of integration defined and which variables affecting the extent of information integration are identified in the literature?
   b) What is the current extent of integration and the status of the variables affecting it in the case supply chain?
3. How can information integration and its impact on supply chain performance be facilitated in steel industry maintenance service supply chain?
   a) What are the performance effects of information integration and how can they be realised according to the literature?
   b) What are the desired performance effects in the case supply chain and what development steps are needed to achieve them?

The first research question seeks to justify the need for information integration in service context and to capture its complex nature in better understandable and manageable components – the elements of integration. The second research question aims at finding a simple way to illustrate the extent of integration and linking it to the contextual setting. The extent is defined through the elements of integration and depends on how far the elements have been developed. A set of contextual factors related to e.g. service characteristics and supply chain relationship is sought that explains the differences in the extent of integration, in other words, can facilitate or restrict the development of the elements of integration. The third research question explores the potential performance effects of the different elements and the extent of integration in the supply chain. Beside the individual performance effects of each element, a connection between the extent of integration and the extent of performance development in general is elaborated.

1.4 Research strategy

1.4.1 The abductive approach of the study

A research approach can be defined as a path of conscious scientific reasoning (Peirce 1931). This study has elements from both theory testing and theory development and can not be purely categorised as inductive or deductive research, but rather abductive. The abductive approach, however, is to be seen as different from a mixture of deductive and inductive approaches (Dubois & Gadde 2002). The abductive research approach has been brought out for instance by Kovács & Spens (2005) and by Dubois & Gadde (2002) as 'systematic combining'. Using abductive reasoning has been argued to be common in case research due to the simultaneous data collection and theory development and the theory building element (e.g. Dubois & Gadde 2002).

The primary aim of abduction is to develop understanding of a 'new' phenomenon and abductive approach aims at theory development (e.g. Arlbjørn & Halldórsson 2002). In abductive research the theoretical frame emerges from the empirical data (Kovács & Spens 2005). The search for suitable theories to an empirical observation in abductive research is called 'theory matching' or 'systematic combining' (Dubois & Gadde 2002). There is a continuous interplay between theory and empirical study: data is collected simultaneously to theory

building, which entails a learning loop or 'back and forth' movement between theory and empirical study (Dubois & Gadde 2002, Kovács & Spens 2005, Taylor *et al.* 2002). This movement enables the researcher to expand his understanding of both theory and empirical phenomena (Dubois & Gadde 2002). In this study, as well, the theoretical and empirical study proceeded in parallel. A rough theoretical 'skeleton' was formed, but new ideas were allowed to emerge from the empirical data. Justification for the ideas was then afterwards sought by means of theory, thus again demonstrating the learning loop between theory and practice.

The abductive approach is concerned with the particularities of specific situations that deviate from the general structure of such situations (Danermark 2001). It helps to identify the aspects of a situation that are generalisable and aspects related to the specific situation itself (e.g. derived from the situational environmental factors) (Kovács & Spens 2005). By interpreting or re-contextualising individual phenomena within a contextual framework, abductive research aims to understand something in a new way, from the perspective of a new conceptual framework (Dubois & Gadde 2002, Danermark 2001). This study has service supply chain environment as the general contextual frame for information integration, but also seeks to explain the variation existing within the context, that is, the differing levels of integration depending on the differing contextual settings of distinct service supply chain dyads.

Abductive research process is a creative iterative process in which the researcher can also introduce a creative element consciously by applying a new theory or framework to already existing phenomena (Kirkeby 1990). Dubois & Gadde (2002) suggest that the framework used in abductive research should be 'tight and evolving'. Tight refers to the degree to which researcher has articulated the 'preconceptions'. The framework should, however, evolve during the study, as empirical observations inspire changes of view of theory and vice versa. Dubois & Gadde (2002) state, that 'the evolving framework directs the search for empirical data'. In this study, the preconceptions were set, for instance, through the context-practices-performance framework (presented later in this thesis in Figure 3) and the presumption on the existence of certain elements and levels of integration. However, the contents of these concepts were allowed to develop throughout the study, finally resulting in a more specifically defined set of theoretical constructs. For instance, the element 'time-related issues' was first included in the research frame as a very vaguely defined construct to see if it actually should be considered as a separate element or rather combined to the other elements. As it constantly remained as an important theme in discussions

with the case companies, it was decided to be considered as a separate element. Consequently, a more detailed definition for it was obtained during the course of research.

Case study methodology applied

The amount of case-based research in SCM is increasing. A case study is an empirical enquiry that explores a contemporary phenomenon in its real life context (Yin 2003). Case studies offer insights into complex interrelationships (Eisenhardt 1989). Case study method has been claimed to be most valuable when the boundaries of a studied phenomenon and context are still unclear and there is no control over behavioural events (Yin 2003, Rowley 2002). Therefore, performing a case study fits well to the purpose of this study as it attempts to bring some structure in describing and analysing the complex and vague concept of information integration, even in a relatively scarcely studied service supply chain environment.

According to Stuart *et al.* (2002), case methodology is appropriate and essential where either theory does not yet exist or is unlikely to apply, where theory exists but the environmental context is different, or where cause and effect are in doubt or involve time lags. This study is combining existing theory and through applying it in a new environmental context – a service supply chain – creating a novel conceptual framework.

Usually only few cases can be studied which is why analytic generalisation is used in case research (Yin 2003, Eisenhardt 1989). To ensure the validity and reliability of case research, the presentation of the research process is of key importance (Seuring 2008). This will increase the value and rigor of case study based research and enable better assessment of the quality of research and drawing of stronger conclusions based on an individual piece of research (Seuring 2008). Careful attention was paid on documenting the research process of this study. The process is described in more detail in Chapter 3.

One of the advantages of the case study method is the flexibility of the research design, which allows accessing various supply chain stages and using a range of data gathering techniques. This should be employed in gaining more understanding in SCM through empirical research. (Seuring 2008). Seuring (2008) further argues that when applying case research in SCM, data should be collected from two or more stages of the supply chain, i.e. at the minimum a dyadic perspective should be taken. In the beginning of this study, the number of supply

chain stages to be included was left, for a while, an open question. Quite soon the perspective evolved to a dyadic one. This was, for instance, because it was noted, that in reality the relationships between the focal company and the service providers were dyadic; there was either very little or no information sharing between the different service providers or service providers and material suppliers.

Case studies typically use multiple data sources (e.g. Rowley 2002). Seuring (2008) has explored case study research in SCM and state that interviews (open, semi-structured or structured) are the most dominant data gathering technique used. This study, similarly, relies on structured interviews as the main data gathering method. The second most central data gathering technique is analysing documents, websites and publications. (Seuring 2008). This study also employed company documents, company visits, and workshops in collecting the research data. The data collection and analysis are described closer in Chapter 3.

A single case design is appropriate when the case examined is special for some reason. The case may be extreme, unique, or has something special to reveal. (Rowley 2002). The number of cases studied can differ from the number of firms studied (Voss *et al.* 2002) and single cases may involve the opportunity to study several contexts within the case (Mukherjee *et al.* 2000). In this study, there is one single case supply chain studied, but it includes six dyads to be analysed providing six individual contextual settings.

In theory building case research the purpose is to identify or describe key variables, identify linkages between the variables and identify 'why' these relationships exist (Voss *et al.* 2002). Appropriate research questions in theory building are (Voss *et al.* 2002):

- What are the key variables?
- What are the patterns or linkages between variables?
- Why should these relationships exist?

The research questions in this study are in line with the suggestions by Voss *et al.* (2002), the key variables being the elements of integration, the levels of integration, the contextual factors, and the performance variables and levels. Patterns between the elements and levels of integration, between the levels and the contextual factors, and between the levels of integration and supply chain performance are sought and justified by the means of literature and through the empirical case.

Research design of the study

According to Rowley (2002), a research design is the logic that links the data to be collected and the conclusions to be drawn to the initial questions of a study. Figure 1 presents the abductive research design of this study.

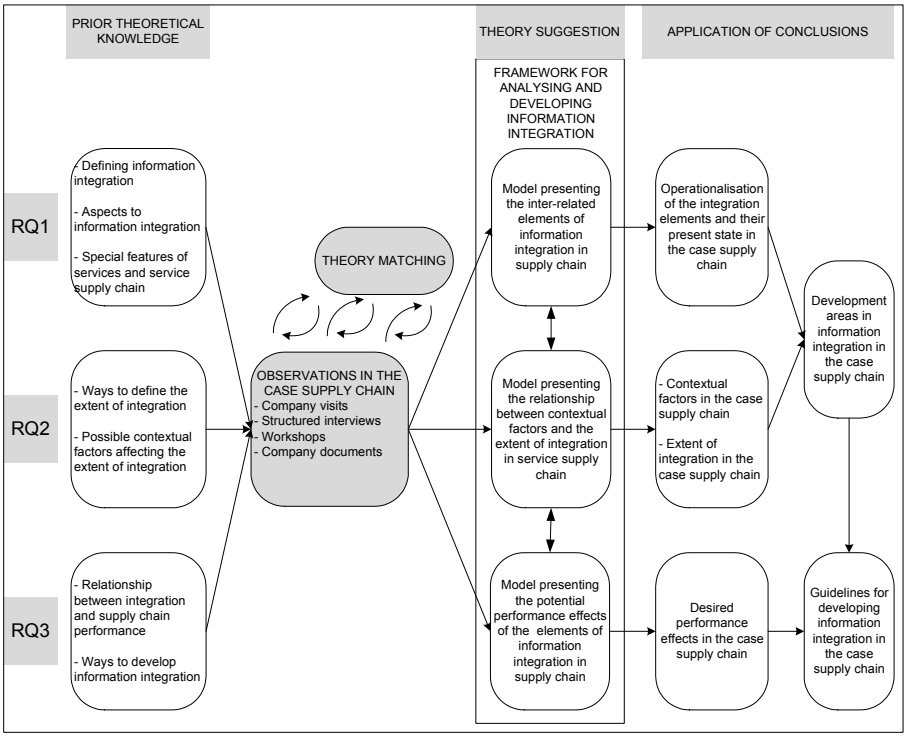

Fig. 1. The research phases of the study.

As a result of the research process, a theoretical framework for information integration is developed to be able to describe, analyse and develop information integration in service supply chain context and to answer the research questions of the study. It should be noted, that although *for expositional purposes* the theoretical framework in this study is presented first, only then followed by the case study, the research process itself has been more iterative, going back and forth between the data and theory (see e.g. Siggelkow 2007).

1.4.2 Theoretical frame of reference

Case studies are particularly suitable for developing new theory and ideas (Voss *et al.* 2002). Theory can be seen as consisting of four components: definitions of terms or variables, a domain (the exact setting in which the theory can be applied), a set of relationships, and specific predictions (e.g. Hunt 1991, Wacker 1998). Cases are specifically useful when there is uncertainty in the definition of constructs (Mukherjee *et al.* 2000). In theory building research, a prior view of the general constructs or categories to be studied and their relationships should be formed (Voss *et al.* 2002). This can be done by constructing a conceptual framework that underlines the research and explains the main things that are to be studied (Miles & Huberman 1994). A priori specification of constructs is valuable, as it allows the researcher to measure constructs more accurately. Thus, if the constructs turn out to be important, the researcher has a more definite empirical grounding for the emerging theory. (Eisenhardt 1989). However, it is also not rare for the research questions to evolve over time and for the constructs to be modified during the course of case-based research (Voss *et al.* 2002).

Theoretical concepts constitute both input and output of an abductive study (Dubois & Gadde 2002). In abductive research there is no need to review all of the related literature beforehand (Strauss & Corbin 1990). In fact, it is not even possible as the empirical fieldwork is conducted parallel to theoretical conceptualisation and the 'need' for theory is generated in the research process (Dubois & Gadde 2002).

A multitude of existing theories from other related research disciplines have been used to explain various aspects of the SCM field (Burgess *et al.* 2006). In the same way, the theoretical background of this study relies on distinct but yet overlapping literatures (Figure 2).

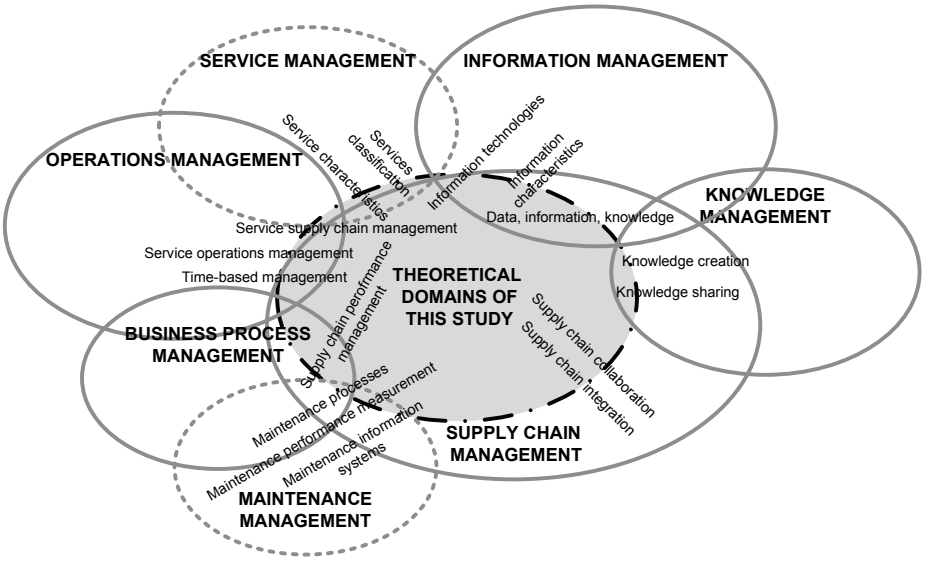

Fig. 2. The main theoretical disciplines impacting the research framework of this study.

The main theoretical discipline in this study is supply chain management. It provides the conceptions underpinning this study based on earlier research around the themes of supply chain integration, collaboration, and performance management. The domain of operations management provides the boundary conditions for making the operations rationalised and more efficient. Maintenance management (contextual approach) is deployed in creating the understanding of the maintenance processes, activities and actors. It also provides the basis for the demands in managing and measuring performance in maintenance processes. The technical implementation of maintenance (techniques, systems, etc.) is, however, left outside of this study and the focus is on external relationships between the maintenance actors. Service management (contextual approach) makes available the important insights regarding the special characteristics of services and the nature of service process. Business process management offers the required understanding on the link between information integration and process development, as integration, indeed, is carried out in business processes. Knowledge management reflects the notion, that information is not necessarily explicit, but should be converted to explicit form in order to be able to share it. The more accurate mechanisms of this transformation, however, are outside the scope of this study. Through the domain of information management

comprehension on the characteristics of information and procedures and technologies in capturing, processing and retrieving information can be gained.

Although SCM is the main discipline of the study, journals from other domains, e.g. business logistics (related to SCM), operations management and knowledge management, were also included in the literature review in order to avoid too narrow view on the research topic and to evade being excessively influenced by certain schools of thought. Journal rankings were used to support the selection of the major journals that were examined more thoroughly (in SCM, e.g. Gibson & Hanna 2003, Gibson *et al.* 2004, Kovács *et al.* 2008, Arlbjørn *et al.* 2008, Zsidisin *et al.* 2007, in OM, e.g. Vokurka 1996, Barman *et al.* 2001, Soteriou *et al.* 1999). Other related journals and journal articles were obtained through search with key words from journal databases and from the references of the articles from the selected journals.

According to Fabbe-Costes & Jahre (2008), this kind of cross-referencing or cross-fertilisation contributes to the theory building. Additionally, having an integrated approach implies being critical and reflective (Fabbe-Costes & Jahre 2008). Paying attention to theory development beyond the traditional boundaries has also been claimed from case researchers in operations management research (see e.g. Stuart *et al.* 2002). Also Ho *et al.* (2002) are in favour of cross-fertilisation of theories of SCM and other related research fields, because such synthesis can strengthen the theoretical ground of conceptual and empirical studies in SCM.

Systematic combining (abductive approach) builds more on refinement of existing theories than inventing new theories (Dubois & Gadde 2002). The theoretical framework is successively modified during the research process and thus, abductive approach creates cross-fertilisation where new combinations are developed through a mixture of established theoretical models and new concepts originated from the confrontation with reality (Dubois & Gadde 2002). It is important in this kind of theory development research to review the emergent theory against existing literature (e.g. Voss *et al.* 2002). According to Eisenhardt (1989), reviewing emergent theory involves asking what is similar, what is different, and why. Consequently, it is crucial to address literature that conflicts with the findings. Literature dealing with similar findings, then again, assists in bundling up underlying similarities between the studies. (Voss *et al.* 2002).

Context-practices-performance framework

Research in SCM has mainly focused on the relationship between SCM practices and supply chain performance. The context, under which SCM practices are implemented, is often left out of the scope. Ho *et al.* (2002) suggest the use of context-practices-performance framework (Figure 3) to obtain a more holistic view on SCM research by considering also the contextual factors possibly influencing the implementation of SCM practices. Context is the setting in which organisational practices are established and applied. The possibilities for the emergence and functioning of organisational practices are created or constrained by the context. There are only few SCM studies focusing on the context-practices relationship (Ho *et al.* 2002). The need for paying attention to the context has been distinguished, however, for instance by Ho *et al.* (2002) and van Donk & van der Vaart (2005b). Also Fabbe-Costes & Jahre (2008) have recognised the lack of reflecting the contingencies issues in supply chain integration research. In this study, the context-practices-performance framework is used as a guiding principle to ensure the comprehensiveness of the research framework.

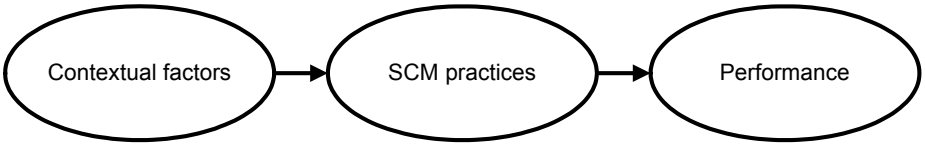

Fig. 3. A context-practice-performance framework of SCM. (Ho *et al.* 2002, Ho & Duffy 2000).

2 Information integration in service supply chain

2.1 Supply chain management

Supply chain has its roots in Porter's (1985) value chain, which is the set of processes a firm uses to create value for its customers. Although originally described as a chain, supply chain can nowadays be defined as *'the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer'* (Christopher 1998). The objectives of the supply chain are to provide service to customers, achieve low operating costs and minimise the assets in the chain (Schary & Skjoett-Larsen 2001).

Supply chain management emphasises the overall and long-time benefit of all parties in the supply chain through co-operation and information sharing (Yu *et al.* 2001). Simchi-Levi *et al.* (2004) define SCM as *'a set of approaches used to efficiently integrate suppliers, manufacturers, warehouses and stores so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time in order to minimize system-wide costs while satisfying service-level requirements'*. The challenge in integration is to coordinate activities across the supply chain so that the enterprise can improve performance: reduce cost, enhance service level, reduce the bullwhip effect, better use the resources and respond effectively to changes in marketplace. Another definition for SCM is presented by Global Supply Chain Forum and also emphasises the integration aspect of supply chain management: *'SCM is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders'* (e.g. Cooper *et al.* 1997). According to Lambert *et al.* (1998) implementing of SCM involves three decisions: the choice of actors, with whom it is critical to link, the choice of processes, which need to be linked with each of these actors, and the level of integration for each process link.

Ho *et al.* (2002) have further extended the Global Supply Chain Forum definition of SCM by incorporating the element of relationships between supply chain members into it: *'SCM is a philosophy of management that involves the management and integration of a set of selected key business processes from end*

user through original suppliers, that provides products, services, and information that add value for customers and other stakeholders through the collaborative efforts of supply chain members'. This definition emphasises three different aspects: value creation, integration of key business processes, and collaboration. (Ho *et al.* 2002).

SCM is generally considered to involve *integration, coordination and collaboration* across organisations and throughout the supply chain (Stank *et al.* 2001). According to Chopra & Meindl (2001), supply chain coordination occurs when all the different stages of supply chain work toward the objective of maximising total supply chain profitability rather than each stage devoting itself to its own profitability. There are a myriad of obstacles that complicate the coordination. These can be divided in incentive obstacles, information processing obstacles, operational obstacles, pricing obstacles and behavioural obstacles. Means to attain coordination include aligning goals and incentives in the supply chain, improving information accuracy and operational performance, designing pricing strategies to stabilise orders, and building partnerships and trust. (Chopra & Meindl 2001). However, the definitions of coordination in SCM research vary: for instance, Chopra & Meindl (2001) define coordination as information sharing between supply chain partners to achieve joint benefits.

According to Christopher (1998), the integration of key business processes in a supply chain is best achieved through collaboration of business partners. Collaboration occurs when firms in the chain set common goals and work jointly to achieve the goals (overall chain performance, value to customer etc.). Resources and information are exchanged between the chain partners. Risks, profits and losses are shared fairly among the chain members. Collaboration can be understood as a form of co-operative inter-organisational relationships, which are 'socially contrived mechanisms for collective action' (Ring & van de Ven 1992). This co-operation can be achieved through either collaboration or compliance (Hardy & Phillips 1998, Hardy *et al.* 1998). Trust forms the basis for achieving collaboration whereas power serves as a mechanism for attaining compliance (Hardy & Phillips 1998, Hardy *et al.* 1998). Stank *et al.* (2001) propose that supply chain collaboration is the construct of coordination, participation and joint problem solving between supply chain partners.

In the SCM research so far, the supply chain management construct has often been perceived narrowly as an extension of integrated purchasing and supply management or integrated logistics and transportation management (Ho *et al.* 2002). Some researchers have, nevertheless, taken a more extensive view on SCM

and emphasised the major linkages between a firm and its supply chain partners upstream and downstream. Examples of these are the supply chain integration studies by Frohlich & Westbrook (2001) and Narasimhan & Jayaram (1998).

Van der Vaart *et al.* (2006) and van der Vaart & van Donk (2008) propose a classification for the level of items used to measure different SCM factors in the supply chain research. The items are divided into supply chain practices, supply chain patterns and supply chain attitudes. These categories can be defined based on the work of van der Vaart *et al.* (2006) and van der Vaart & van Donk (2008) as follows:

- Supply chain (SC) *practices* can be defined as tangible activities or technologies that are in a crucial role in the collaboration of focal firm with its supply chain partners (e.g. Electronic Data Interchange (EDI), Vendor Managed Inventories (VMI)).
- SC *patterns* are interaction patterns between the focal firm and its supply chain partners (e.g. regular visits to supplier's facilities, frequent face-to face communication).
- The SC *attitudes* refer to the attitudes of supply chain members towards each other or towards SCM in general (e.g. related to continuity expectations of the relationship, joint problem solving, and shared responsibility between partners).

Van der Vaart & van Donk (2008) suggest that future research in SCM should take into account all of the three categories and their interrelations.

2.2 Integration in supply chain

Stevens (1989) originally identified four stages of supply chain integration:

- *Baseline.* Fragmented operations within an individual company. Planning very short term, almost reactive.
- *Functional integration.* Limited integration between adjacent functions. Focusing on the inward flow of goods. Poor visibility of real customer demand.
- *Internal integration.* Involves integrating the aspects of supply chain that are directly under the control of the company.
- *External integration.* The scope of integration is extended outside the company to embrace suppliers and customers.

Since the definition of Stevens the integration has moved towards a broader channel or network perspective (e.g. Spens 2001, Fawcett & Magnan 2002). The focus of integration has shifted from functions (departments or functional areas) to processes (e.g. Bowersox *et al.* 2000) and from internal to external integration (e.g. Holma 2006). It has been suggested that the concept of supply chain integration originally stems from the notion of vertical integration and this leads to the conventional definition of supply chain integration as a uni-dimensional construct (Akkermans *et al.* 1999, Stonebraker & Liao 2004). Stonebraker & Liao (2004) argue that instead, supply chain integration should be seen as a continuous and multi-dimensional variable.

Pagell (2004) defines supply chain integration as *'a process of interaction and collaboration in which companies in a supply chain work together in a co-operative manner to achieve mutually acceptable outcomes'*. Supply chain integration can also be defined *as 'the degree to which an organisation strategically collaborates with its partners and manages intra- and inter-organisational processes in order to achieve efficient and effective flows of products, services, information, money and decisions'* (e.g. Frohlich & Westbrook 2001, Bowersox *et al.* 1999, Zhao *et al.* 2008). Mejias-Sacaluga & Prado-Prado (2002) see managing integration in a supply chain as a synonym to relationship management. Different concepts have been suggested in the SCM literature to describe an integrated supply chain relationship. Despite the diversity of concepts, common characteristics of an integrated (or collaborative) relationship can be identified, including long-term commitment, open communication and information sharing, sharing risks and rewards, and cooperative and continuous improvement (e.g. Gentry 1996).

Growth of information technology and communication capabilities enhance the ability to integrate the supply chain (Stank *et al.* 2001). Effective integration has been proposed to involve mutual understanding, a common vision, shared resources, and achievement of collective goals (Kahn & Mentzer 1996). Sahin & Robinson (2002) suggest that the degree of information sharing and decision-making coordination are the two major components of supply chain integration at operational level.

The elements included under the concept of integration vary. To give some examples, Paulraj *et al.* (2006) divide supply integration into four distinctive elements: relational integration, process integration, information integration and cross-organisational teams. Bagchi & Skjoett-Larsen (2003) view integration through the elements of information integration and organisational integration.

Christopher (1998) states, that supply chain integration implies process integration, but by this refers to similar aspects as Paulraj *et al.* (2006), such as buyer-supplier collaboration, common information systems and shared information. Lee (2000) divides supply chain integration into three dimensions: information integration, coordination and resource sharing, and organisational relationship linkage. Thus, three main aspects in integration seem to be the information integration (and related systems and technologies), organisational or relationship integration, and process integration.

Generally, integration research has focused on three perspectives: integration as a series of interactions, integration as collaborative behaviours, or a composite of the two (e.g. Kahn & McDonough 1997, Ellinger *et al.* 2000, Griffin & Hauser 1996). Kahn & Mentzer (1996) are in favour of the composite approach and emphasise that collaboration and interaction should be seen as separate processes. They further state that there are situations requiring differing levels of interaction and differing levels of collaboration based on the complexity of the situations.

Another viewpoint to integration is through layers. Fabbe-Costes & Jahre (2008) identify four layers of integration that are interconnected:

- Integration of *flows* (material, information, financial),
- integration of *processes and activities*,
- integration of *technologies and systems*, and
- integration of *actors* (structure and organisations).

The number of layers included in the integration studies varies (Fabbe-Costes & Jahre 2008). For instance, Vickery *et al.* (2003) stress the importance of technologies. Frohlich & Westbrook (2001) concentrate on operational aspects of information and physical flow. Some studies focus on relational issues (e.g. Carr & Smeltzer 2002). Information technology/systems layer is, as it turns out, often not included in supply chain integration, while other research papers consider it as a major aspect of integration (Fabbe-Costes & Jahre 2008). But when thinking of, for instance, information integration in a supply chain, actually all four layers should be included at some level. After all, information integration involves integrating the information flow flowing through processes, which necessitates integration of information systems or technologies and the commitment and willingness of the actors in the supply chain to share the information and technologies.

The reach (or scope) of integration, in other words the nature and number of organisations or participants included in the integrated supply chain, varies (see

e.g. Mentzer *et al.* 2001, Jahre & Fabbe-Costes 2005). External integration can be dyadic, triadic or extended. Dyadic integration refers to integration between focal company and suppliers or customers. Integration with customers is called downstream integration and integration with suppliers is known as upstream integration. Triadic integration involves integration between focal company and customers and suppliers. Extended integration refers to integration between more than three parties along the supply chain and can involve customers' customers, suppliers' suppliers, or other stakeholders such as service providers. (Fabbe-Costes & Jahre 2008).

In this study, a dyadic view to integration is taken. In SCM field, generally, there has been a call for research dealing with at least three echelons in the supply chain and not merely two (e.g. Mentzer *et al.* 2001). However, the current definitions of supply chain, SCM and integration, although emphasising the network perspective and the collaborative effort between companies, do not provide any restrictions concerning the adequate number of echelons. In fact, in most real-life cases, the total supply chain actually involves a much greater number than just three echelons, which implies that even a triadic perspective in research would not adequately cover the whole supply chain. Moreover, van Donk & van der Vaart (2005b) present arguments for adopting the dyadic perspective when examining integration, as

- for each dyad in the supply chain, circumstances can be quite different and result in link-specific arrangements,
- the problem of dividing the benefits of integration should be solved in the dyad, and
- SCM practices are developed and managed in the one-to-one relationship in a dyad.

Consequently, van Donk & van der Vaart (2005b) also criticise the SCI research for measuring integration as an organisational concept instead of a dyadic concept. However, these arguments also suggest that the inclusion of a third supply chain echelon is not a necessity when examining integration, and might even add redundant complexity into the research setting.

'The more integration – the higher performance' is not necessarily the best and only approach to integration. The integrated SCM is not inevitably the best solution in all business environments and supply chains and has been criticised for instance by Bask & Juga (2001). Instead of fully integrated supply chains Bask & Juga (2001) bring out the idea of *loosely coupled* supply chains.

Additionally, Bagchi & Skjoett-Larsen (2002) and Bagchi & Skjoett-Larsen (2003) argue that the preferable level of supply chain integration depends on various situational variables related to the focal company (power-dependence-relationship, core competence), industry (maturity), the competitive environment (market dynamics), and the nature and type of products.

Supply chain integration research has been widely criticised. There are a myriad of different constructs and measurements for supply chain integration in the research published (Ho *et al.* 2002, van der Vaart & van Donk 2008). The potential interactions between various aspects of integration are often ignored. The majority of the empirical studies dealing with integration have been either single case studies or surveys. The response rates in surveys have generally been low and the choice of respondents and populations often limit the validity and generalisability of the results. The problem of case studies is the generalisability of the results, especially if there is no clear theoretical framework supporting the case study. Researchers have apparently also failed to build on the earlier research done (van der Vaart & van Donk 2008), which hinders the theory development in the field of SCI.

2.3 Special characteristics of service supply chain

Service can be defined as *'An act or performance offered by one party to another. Although the process may be tied to a physical product, the performance is essentially intangible and does not result in ownership of any of the factors of production'* (Lovelock 2001). Business services are defined as services delivered to organisations (e.g. Homburg & Garbe 1999). Business services often have to be customised to meet the purchasing organisations' needs (Fitzsimmons *et al.* 1998). Often services have to be delivered physically close to the customer which complicates the delivery structure for services (Åhlström & Nordin 2006). The service supply chain can be defined as *'the network of suppliers, service providers, customers and other supporting units that performs the functions of transaction of resources required to produce services; transformation of these resources into supporting and core services; and the delivery of these services to customers'* (Baltacioglu *et al.* 2007). A core service is the ultimate product delivered to the customer and providing benefit to the customer. A number of supporting services may be needed to deliver the core service.

Service supply chain management is defined as *'managing information, processes, capacity, service performance and capital from the initial supplier of*

the chain to the final customer' (Ellram *et al.* 2004). Baltacioglu *et al.* (2007) refer in their definition of service SCM to management of information, processes, service performance and resources. Resources include the labour, capital, physical commodities and potential support services needed to deliver the service. Both definitions highlight the meaning of information flow. According to Baltacioglu *et al.* (2007) managing information is closely related to managing technology, as managing technology is important to ensure the effectiveness of information systems. Information flows are especially important in service supply chains to manage the uncertainty related to services (Field & Meile 2008). In particular, information flow is critical in terms of identifying demand, sharing information, establishing expectations through a service level agreement or statement of work, clearly defining the scope of the work, and the skills required of service providers and feedback on performance. Moreover, information flow is essential in monitoring the ongoing performance to determine the timing and amount of payment. (Ellram *et al.* 2004).

Companies are still frequently managing services equally to materials and using the same information systems (e.g. ERP, Enterprise Resource Planning) for services and materials, although services have special characteristics and service delivery differs substantially from material deliveries. Bowen & Ford (2002) summarise the differences between tangible products and intangible services as being related to the measures used to access the effectiveness and efficiency and differences in production (delivery) strategies and production (delivery) processes. The need to recognise differences between manufacturing and services and develop models and empirical knowledge that especially focus on services has been highlighted e.g. by Nie & Kellogg (1999) and Baltacioglu *et al.* (2007).

Services are often described as being intangible, inseparable (simultaneous production and consumption), heterogeneous, perishable and labour intensive (e.g. Kellogg & Nie 1995, Nie & Kellogg 1999). One more special aspect is the customer involvement in the service process, called customer influence by Kellogg & Nie (1995). According to Nie & Kellogg (1999), these characteristics are interdependent and partly overlapping. Kellogg & Nie (1995) consider the customer influence as the most dominating characteristic of services.

Services are also usually more difficult to visualise and to measure than physical products. Measuring inputs and outputs in services necessitates a more subjective approach than measuring them in manufacturing context (Bowen & Ford 2002) and some of the input is usually produced by customer co-production (Kingman-Brundage 1995). The participation of customer to the service delivery

process generates complexity in service operations, which is not inherent in manufacturing operations. Often customers are also co-suppliers and the service chain is bi-directional, which is called customer-supplier duality (Sampson 2000). Customer may provide input to act on to the service process, e.g. a broken piece of equipment (Åhlström & Nordin 2006). The service quality many times depends not only on the performance of the service provider but also the performance of the customer in interaction with the service provider (O'Farrell & Moffat 1991). The perishability of services creates challenges in managing service demand, utilising the capacity, planning the services and scheduling the labour resources. The heterogeneity of the services means that services are often either intentionally or unintentionally customised. (e.g. Fitzsimmons & Fitzsimmons 1998, Nie & Kellogg 1999). The interface between service providers and service buyer is claimed to require more communication as interface with material suppliers (Ellram *et al.* 2007).

In a service supply chain (Ellram *et al.* 2004, Sengupta *et al.* 2006) human labour forms a crucial component of the value delivery process. It is difficult to standardise and centralise procedures as variation and uncertainties in the output are high due to high degree of human involvement. Also Åhlström & Nordin (2006) have noted the importance of people and their competence for services, which causes problems in service supply relationships, as such a competence is difficult to specify in a contract. Services can not be inventoried (the perishability characteristic) and thus the focus in service supply chain is on managing capacity, flexibility of resources, information flows, service performance, and cash flow. Demand fluctuations can, however, be buffered with capacity (e.g. Ellram *et al.* 2007). If there is not enough capacity to meet the demand, the service runs the risk of losing customers. On the other hand, once the available capacity is unused, it has no value and the costs of the idle capacity makes the service firm uncompetitive with competitors who have better managed to match the demand and capacity. (Bowen & Ford 2002). The performance of a service provider is difficult to measure, the specification of a desired service is less precise than for a product and it is difficult to judge if the services being provided are meeting expectations (e.g. Ellram *et al.* 2007, Ellram *et al.* 2004, Fitzsimmons *et al.* 1998). In maintenance, for instance, you can easily see that a device has been repaired, but how can you assess whether it has been done effectively enough?

Services vary with the provider and there are often broader specifications for the service output with a range of acceptable outcomes. The costs of a service vary depending on changing scope and requirements set to the service and are

situation specific. Costs are often difficult to determine exactly in advance and are renegotiated later. Recovering from or fixing failures in services differs from the manufacturing of tangible products (Bowen & Ford 2002) because service delivery failures can not be singled out and isolated (Åhlström & Nordin 2006). Often the failure is identified and fixed during the service delivery process. What comes to problem solving in services, there are no set processes and it is often subjective. (Ellram *et al.* 2007). Åhlström & Nordin (2006) found out in their study that most of the knowledge required for delivering a service was embedded in employees' minds and that experience was difficult to document. They conclude that this kind of tacit knowledge is presumably more evident and significant in many service businesses compared to manufacturing businesses.

Grönroos (1998) emphasises the process nature of services. In service operations the term 'process' stands for the necessary activities, their sequence and inter-relationships as an organisation transforms inputs into services (Christensen & Donovan 1999). Processes are particularly essential in service delivery, as one of the special features of services is the overlap between the service and service delivery process (e.g. Slack *et al.* 1995). In service setting, the 'product' consists of both the outcome and the process needed to produce the outcome. The outcome is the result that the customer receives as a result of the service delivery process (in maintenance, for instance, a repaired device). Defining services as processes or sets of inter-related activities shows that the company doing the specification knows exactly how the services are produced (Axelsson & Wynstra 2002). Defining the processes should be done already before the relationship with a service provider is initialised. If the service processes are inadequately defined, transferring the responsibility for the processes to the service provider is difficult. (Åhlström & Nordin 2006).

The process view, however, is not the only way to define services. According to Axelsson & Wynstra (2002) services may be defined based on

- *input*, i.e. the resources and their competence,
- *process/throughput*, i.e. how to fulfil the goal in terms of activities
- *output*, i.e. the expected results or function, or
- *outcome*, i.e. the value of the service in monetary terms or service level, functions, activities, performance or service level, and competence.

The different ways of defining services have different implications on the companies involved. Process view leaves the responsibility to the service buyer, whereas output and outcome approaches emphasise the importance of service

provider's competence and trusting relationships. An output/outcome method for specifying services may be particularly suitable for complex services in a close collaborative relationship. (Åhlström & Nordin 2006, Axelsson & Wynstra 2002).

The duration of buyer-supplier relationship has generally been estimated to be more long-term in non-manufacturing organisations (services) compared to manufacturing organisations (Ellram & Krause 1994). Field & Meile (2008) suggest that based on these results the buyer-supplier relationships in service supply chains tend to be developed towards tight partnerships in time. Long-term collaboration in service supply chain helps the service firms to customise service offerings to the specific needs of customers of choice by identifying their long-term requirements, expectations, and preferences, thus encouraging new service ideas and business opportunities.

Research concerning information integration in a business service context is still scarce. Very few pieces of empirical research pertaining to the topic of this study can be found in the literature. Mortensen & Lemoine (2008) have examined the level of integration and ICT use between third party logistics service providers and manufacturers, but merely from a business process perspective. One step closer to this study is the study by Minkus & Nobs (2006) discussing improving the use and exchange of information in industrial services with an IT solution. However, their perspective is focusing on information technology. Persona *et al.* (2007) have analysed the impact of e-business technologies on maintenance management and supply chain integration. Salmela & Lukka (2005) have investigated the development possibilities of e-business in a network between small local maintenance service providers and large forest industry customers.

2.4 Elements of information sharing and integration

Information integration refers to sharing of pertinent information among the members of a supply chain (Lee & Whang 2001). According to Lee & Whang (2001) this involves sharing of any type of data (information) that could influence the actions and performance of the other supply chain members. However, collaborative arrangements also involve knowledge transfer that is both explicit and tacit (Lang 2004). Consequently, information integration in this study in service supply chain context is defined as *sharing of pertinent data, information and knowledge between supply chain members.*

The concepts of data, information and knowledge are inter-related. According to Kumar & Thondikulam (2006), knowledge can not be effectively obtained

without considering its media: data and information. Knowledge and information can be stored and transferred through data. A piece of data, then again, only becomes information or knowledge when its receiver interprets it. Knowledge and information flow in organisations in the form of data transfer through media such as records, instructions, drawings, minutes of meetings, electronic files, or web pages. (Kumar & Thondikulam 2006).

Data can be defined as facts (Alter 1999, Pollock & Hodgson 2004). Information is data which has been given a meaning (Pollock & Hodgson 2004) or data whose form and content are appropriate for a particular use (Alter 1999). Information can also be considered as data that is of potential value in decision making (e.g. Small & Sage 2006). Knowledge is much harder to detach, transfer, and share and much more difficult to assimilate and understand than information (Brown & Duguid 2002). Miller & Morris (1999) see knowledge as the intersection of information, experience, and theory. Explicit knowledge can be articulated and codified and transmitted easily (Lang 2004). Nonaka (1991) views tacit knowledge as consisting partly of technical skills and involving a cognitive dimension consisting of mental models, beliefs and ingrained perspectives. According to Lang (2004), tacit knowledge resides in social contexts that depend on individual and organisational levels. One approach is to view data, information, and knowledge as a value chain: information has more value than data, and knowledge possesses more value than either data or information (Desouza & Awazu 2004).

Information sharing has been shown to offer a central enabler of effective supply chain management (e.g. Cooper *et al.* 1997, Tan 2002, Min *et al.* 2005, Min & Mentzer 2004, Moberg *et al.* 2002a). For example, companies such as Cisco and Dell have successfully utilised information sharing for linking manufacturing operations with upstream and downstream members of the supply chain (e.g. Zhou & Benton 2007). Information provides the visibility needed to make decisions that improve the company and overall supply chain performance (Chopra & Meindl 2001). The extent of information sharing in a supply chain is expanding and even the possibility of sharing information among competitors has been discussed (Lee & Whang 2000). Information flow has been extensively described and explored (e.g. Chibba & Rundquist 2004), but it is still difficult to find measures for information flow and information integration. The question, what metrics should be used to evaluate the level of integration and the overall performance of supply chain still needs further consideration (e.g. Lambert *et al.* 1998).

Different aspects to information integration (i.e. information sharing between supply chain members) exist in the extant literature. In this study these aspects are referred to as 'elements' of information integration, each element being an integral constituent of the notion of information sharing in a supply chain. The inter-relation between process integration and information sharing has been one view in the literature (e.g. Alter 1999, Bhatt 2000) and is referred in this study as the 'processes and activities' element. A second issue that is commonly mentioned is the technology in information sharing (e.g. Zhou & Benton 2007), which forms the 'information technology use' element in this study. In addition, Li & Lin (2006) distinguish two aspects of information sharing: level of information sharing and quality of information sharing. Level of information sharing implies the extent to which critical and proprietary information is communicated to a supply chain partner (Mohr & Spekman 1994, Monczka *et al.* 1998) and is in this study covered by the element 'information sharing practices'. Quality of information sharing (or communication) encompasses the accuracy, timeliness, adequacy, and credibility of information shared (Moberg *et al.* 2002a, Mohr & Spekman 1994, Monczka *et al.* 1998, Daft & Lengel 1986) and is included in the element 'information attributes' in this study. Information participation (Mohr & Spekman 1994, Zailani & Rajagopal 2005) is the fifth aspect of information sharing found in the literature and refers to the extent to which partners engage jointly in planning and goal setting (Mohr & Spekman 1994) thus reflecting the collaboration aspects in integration. In this study, the 'collaborative foundation' element elaborates these issues. Finally, information flow has been considered as an integral component of time-based management, hence emphasising the need to consider the time-related issues in information sharing. Thus, the sixth element included in this study is 'time-related issues'. Next, the six different elements of integration will be described and defined more accurately.

2.4.1 Processes and activities

According to Talwar (1993), a process is a sequence of pre-defined activities executed to achieve a pre-specified type or range of outcomes. Davenport & Short (1990) emphasise the use of resources of an organisation in achieving the end result of a process and define business process as the logical organisation of people, materials, energy, equipment, and procedures into work activities designed to produce a specified end result. High-level processes can be further divided to process elements, activities and tasks (Armistead 1996). Processes may

extend outside an organisation (e.g. Tinnilä 1995) and therefore process and supply chain focus should be combined when analysing processes (McAdam & McCormack 2001).

Some recent views in research connect the integration to process management and design in supply chain (e.g. Lambert *et al.* 2005). From the process perspective, external integration is seen as unified control of functions and processes across trading partners (Lambert *et al.* 2005, Germain & Iyer 2006). In fact, supply chain members often couple information sharing with process improvements (Lee & Whang 2000). However, McAdam & McCormack (2001) state that there is little evidence of organisations actually exploiting the integration of business processes in their supply chains. Moreover, Kaipia & Hartiala (2006) note, that the connection between shared information and process development is rarely considered. McAdam & McCormack (2001) conclude that all process-based management techniques advocate identifying and documenting core processes and suggest a series of steps to facilitate the changes in them. The core processes rely on communication of information through them (McAdam & McCormack 2001). Chen *et al.* (2007) highlight the importance of process orientation in integration. Moreover, Bagchi & Skjoett-Larsen (2003) have indicated that highly integrated companies have adopted process orientation. Kemppainen & Vepsäläinen (2003) define three development stages for (process) integration, also involving IT development moving from operational (functional systems) via sequential process (enterprise-wide integration) to inter-enterprise process integration and inter-organisational systems.

2.4.2 Information technology use

Much of supply chain integration literature suggests that IT tools are required for integration (e.g. Narasimhan & Kim 2001). Information technology exploitation can effectively support the integrative activities and it should be considered strategically. Information technology consists of the hardware and software used in supply chain companies to gather, store, and analyse information (Chopra & Meindl 2001). Lee & Whang (2000) have stated that the availability of cost-effective information technologies is a key driver of SCM. Technologies enable companies to replace costly logistics flows and inventories by information (Lee & Whang 2000). The primary objective of IT is to lead users to the information they need. This entails creating, gathering, storing, accessing, and making available the

right information that will result in developments of insight for the organisation's users (Davenport & Prusak 1998).

The levels of IT functionality can been seen as ranging from operational through planning or tactical level to the strategic level. Similarly, the scope of IT use moves from merely transactional (executing and recording transactions, gathering information) to highly analytical (focusing on analysing information on a broader level). (Chopra & Meindl 2001). Shah *et al.* (2002) suggest that a proper alignment between the development stage of supply chain (degree of coordination) and integration of inter-organisational information systems is critical to success of the supply chain relationship. They define three levels of inter-organisational information systems integration based on Riggins & Mukhopadhyay (1994) classification. Level 1 refers to low integration where only a small number of documents is transmitted electronically between the supply chain members. At level 2 (moderate integration) supply chain partners communicate electronically using multiple document sets, but the ability of partners to manipulate shared data sets and documents is limited. Level 3 is defined as high integration entailing complete systems integration between supply chain firms and the ability of supply chain partners to change the shared data. According to Shah *et al.* (2002) the requirements for information system integration capabilities increase as the length of a supply chain relationship and breadth of coordination in the relationship increases.

IT by itself does not matter to the business – but information does, and as long as information matters, the evolution of IT will, too. There is a strong trend toward IT standards due to the need for interconnectivity between different systems, new software models and goal to reduce the cost of system development and maintenance. (e.g. Simchi-Levi *et al.* 2004). Stefansson (2002) states, that the information systems architecture in a supply chain must be capable of linking or coordinating the individual information systems of the supply chain partners. Stefansson (2002) also recognises a need for less expensive methods of sharing data in supply chains to enable the participation of SMEs in data sharing. In the future, the application connections and information will be loosely coupled and instead of IT integration we can talk about *interoperability*. There will also be less and less human involvement in the information flow. (Pollock & Hodgson 2004).

IT, however, is no substitute for other efforts towards integration (Pagell 2004). In fact, Pagell (2004) found almost no evidence at all of IT itself being a key enabler or inhibitor of integration in his study. Mechanisms for face-to-face integration were perceived more important than information systems. However, in

situations, where real-time face-to-face communication is difficult, formal communication supplemented with information systems seems to facilitate integration. (Pagell 2004).

Patterns of IT use can affect the coordination and performance in a supply chain relationship. According to Sanders (2008) IT use for exploitation is an antecedent to operational coordination and IT use for exploration an antecedent to strategic coordination. In Sanders' (2008) study, operational coordination refers to information sharing to achieve efficient task execution and strategic coordination is defined as information sharing for purposes of organisational planning and positioning strategies. Exploitation is in line with the 'automating' purpose of IT and entails improving current methods to solve problems. Exploration, respectively, serves the 'informating' purpose of IT and involves uncovering new methods to solve problems, thus to support organisational decision making and sharing of ideas.

Studies of Pagell (2004) and Sanders (2008) suggest that IT is used more for automation of processes and enhancing the efficiency of tasks than development of new methods and ideas. However, to achieve full strategic and operational benefits of IT use, both types of uses for IT should be deployed (Sanders 2008).

2.4.3 Information attributes

The most common information shared in supply chains include inventory levels, sales or demand data, order status for tracking and tracing, sales forecasts and production or delivery schedules (Lee *et al.* 2000). Other information often shared in supply chain includes performance metrics and capacity. Performance metrics is related to product quality data, lead times, queuing delays at workstations, and service performance. Sharing this kind of information can assist in identifying the bottlenecks of the chain and improve the overall chain performance. (Lee & Whang 2000). Sharing capacity information can contribute to mitigating potential shortage gaming behaviour and help the downstream supply chain partners to better coordinate and prepare against possible shortages.

The characteristics of information to be shared in a supply chain include, among others, the type or form, availability, and quality. Especially the suppliers (of materials and services) are dependent on the type and quality of information passed on them by the focal company (buying company) (Sanders 2008). *Form* (or type) describes the mode and medium in which the information is delivered to its users or through which the information is made available. (Ahituv 1989,

Freiden *et al.* 1998). Thus, it describes how the information is distributed and how it can be accessed. The form of information can be described through four categories (modified from Minkus & Nobs 2006):

- *Data and information in databases:* Information stored in information systems and local databases.
- *Documents provided electronically:* Information stored locally or on shared network drives and shared by e-mail.
- *Paper-based documents:* Information exchanged by fax, mail or personal hand-over.
- *Informally shared information:* Information shared through informal contacts with other employees, i.e. via telephone, meetings, e-mails and conversations.

Four common perspectives to describe the information *quality* are accuracy, usefulness, reliability, and completeness. (e.g. Baroudi & Orlikowski 1988). *Accuracy* indicates the degree of conformity of the received information compared to its actual content; in other words, whether the information is free of error or not. Accurate information conforms to or presents the actual characteristics of the phenomena that it purports to describe (Freiden *et al.* 1998). Inaccurate information can be misleading or harmful to its users. *Usefulness* (or utility) of information describes the usefulness of information for a certain purpose. The format and mode of the information is such that it can be used easily in everyday use without any special skills or tools (Parker 1998). *Reliability* of information is the probability that information is correct. Meadow & Yuan (1997) divide reliability into reliability of content and reliability of source. Reliability of content is a synonym or near-synonym to accuracy. Assessing the reliability of an author or corporate source of information may be done by rating the previous content reliability of information from the source or the circumstances under which a particular message originated. (Meadow & Yuan 1997). *Completeness* refers to how complete the information about the subject on-hand is or how much of the target phenomenon is described by the information available. Incomplete information may be completely useless or have reduced value to its users. (Freiden *et al.* 1998).

The *availability* of information refers to how often the information is available when it should be. By Parker (1998) availability is defined as the usability of information for a purpose. This ensures that information and vital services are available to users when required (Parker 1998). For instance, Gustin *et al.* (1995) found out that high levels of information availability are associated

with successful implementation of integrated distribution concept. Information availability supports better decision-making at the strategic, tactical and operational level. Integrated firms seem to place more importance on providing information support for management and control functions. (Gustin *et al.* 1995).

2.4.4 Information sharing practices

SCM practices can be defined as the set of activities undertaken by an organisation to promote effective management of its supply chain (Li *et al.* 2006). Thus, information sharing practices refer to the activities undertaken to advance effective sharing of information in an organisation's supply chain.

Frequent communication and interaction has been considered an important mechanism in efficient management of information flow (e.g. Bowersox *et al.* 2000, Barratt 2004). Communication methods are the enabling technologies for sharing information (Sahin & Robinson 2002). Carr & Kaynak (2007) divide the methods to traditional communication methods (telephone, fax, e-mail, written communication, and face-to-face contact) and advanced communication methods (computer-to-computer links, EDI (Electronic Data Interchange), ERP (Enterprise Resource Planning), etc.). Face-to-face interaction is considered important for information sharing in buyer-supplier relationships and advanced communication technologies just provide additional opportunities to share information (Wognum *et al.* 2002). However, use of advanced communication methods, such as electronic mail, electronic data exchange, fax, computer-to-computer links and EDI broadens and deepens accessible information about business activity (Bhatt 2000). Carr & Smeltzer (2002) have suggested that suppliers and buyers interact more frequently when they use IT because it facilitates the communication. On the other hand, according to a study by Carr & Kaynak (2007) advanced communication technologies did not have any critical influence on information sharing between firms.

Different ways to define and describe the extent (or volume) of shared information exist. Gavirneni *et al.* (1999) describe the amount of information shared through the concepts of none, partial, and full information sharing. Samaddar *et al.* (2006) use low or high volume to describe the amount of information shared. Moreover, they add the dimension of strategic importance of the shared information that ranges from operational to strategic scope. Lamming *et al.* (2001) have described the varying degrees of information sharing between supply chain partners through the concept of transparency. They categorise the

varying degrees of transparency moving from opaque (no information sharing) through translucent (outline information shared) to transparent, which means sharing information on a selective and justified basis. In the transparency stage the development of information is seen to lead to shared knowledge and collaborative abilities. Supply chain relationships are likely to contain elements of all the three categories (Lamming *et al.* 2001). However, it is difficult to imagine a situation, where a whole dyadic relationship could be categorised as being opaque. The presupposition, indeed, is that when a supply chain relationship in general exists, at least some information is being shared between the partners related to some processes or activities.

2.4.5 Collaborative foundation

Handfield & Nichols (1999) argue that without a foundation of effective supply chain relationships, any effort taken to manage the flow of information or materials in a supply chain is likely to be unsuccessful. Similar views have been presented in the literature related to information sharing in particular. Bailey & Francis (2008) state that it is not sufficient to consider only the information sharing itself, but there is a need for other socio-technical factors to be present. They suggest that the 'relationship dimension' should be taken into account when considering information sharing. Also Li & Lin (2006) emphasise the role of inter-organisational relationships in facilitating information sharing and information quality. Information sharing needs to be preceded by the incentives for collaboration and a foundation level of mutual trust and openness (Bowersox *et al.* 2000). Moreover, Wong & Boon-itt (2008) consider it likely that relationship quality factors, especially trust, affect supply chain integration in general. Bailey & Francis (2008) summarise the literature dealing with factors affecting the effective management of supply chain information. Accordingly, information sharing should be combined with integration of incentives and decision-making (Simatupang & Sridharan 2005), integration of measurement systems (Rodrigues *et al.* 2004), and functional process alignment (Barratt 2004).

The collaborative foundation needed for information integration can be described along several characteristics. According to van Donk & van der Vaart (2005a), mutual trust is a necessity to start with integrative activities in a supply chain. An integrated supply chain relationship is characterised by high level of trust (Maloni & Benton 2000). Trust is one's belief that one's supply chain partner

will act in a consistent manner and do what he/she says that he/she will do (Spekman *et al.* 1998). Kumar *et al.* (1995) divide trust in two elements:

- Trust in the partner's *reliability*, which refers to the belief that the partner stands by its word, fulfills promised role obligations and is sincere.
- Trust in the partner's *benevolence*, in other words the belief that the partner is interested in the firm's welfare and will not take unexpected actions that negatively affect the firm.

Shapiro *et al.* (1992) add a third component of trust, referred to as 'identification-based trust', which means that each party in the supply chain relationship shares the other party's goals.

Willingness to share information requires trusting relationships (Fawcett *et al.* 2007). It has been claimed that a company's willingness to share information, i.e. openness to share relevant information honestly and frequently, ultimately determines the extent of information sharing that takes place (Lee *et al.* 2000, Mendelson 2000). Managers can impact the level of willingness by supporting programs that allow individuals to develop initiatives and opportunities to share knowledge (Hammer 2004). The scope of information shared usually expands as trust is established between the chain partners (Bowersox *et al.* 2000). Especially, a high degree of trust encourages the exchange of tacit knowledge in collaborative relationships (Lang 2004). The level of trust in a supply chain relationship has been described by using the categories 'low', 'medium', and 'high' (e.g. Sheu *et al.* 2006). Payne (1995) summarises the typical themes in empirical studies to measure trust perceived by different supply chain partners as sharing of values, cooperation in problem solving, working together to achieve common goals, and sharing of vital information. Generally, deeper levels of trust necessitate repeated cooperative interaction in order to be formed (Ross *et al.* 2007). Trust needs to be developed over a period of time and Sahay (2003) considers the length of period that the relationship lasts also as an indicator of trusting relationship between the supply chain parties.

Trust is related to commitment (e.g. Goffin *et al.* 2006). In fact, according to Morgan & Hunt (1994) commitment is present only if there is trust. Commitment refers to the willingness of supply chain partners to exert effort on behalf of the relationship (Porter *et al.* 1974). It is most frequently demonstrated by committing resources to the relationship, which may be in the form of an organisation's time, money, facilities, etc. (Zailani & Rajagopal 2005, Sheu *et al.* 2006). Maloni & Benton (2000) describe commitment based on Mohr & Spekman (1994) as the

feeling of being emotionally impelled to maintain a long-term relationship. High level of commitment is characteristic for an integrated supply chain relationship (Maloni & Benton 2000). Increased levels of communication have been found to be related to commitment (Morgan & Hunt 1994).

Bowersox *et al.* (2000) have emphasised the role of shared vision and objectives in inter-firm relationships. For instance, Gimenez (2006) has used joint establishment of objectives as a measure for external integration in supply chain. Also Whipple & Russell (2007) highlight the meaning of setting joint business goals, especially when implementing more strategic collaboration, which they call collaborative process management. Pagell (2004) goes even further and considers the level of consensus, i.e. alignment of goals as not merely a driver, but rather an indicator of integration.

Sharing resource information and pooling resources enables collaborative planning in the supply chain suggested by Kulp *et al.* (2004). Shared resources were also identified by Bagchi & Skjoett-Larsen (2003) as a means of accomplishing information integration.

2.4.6 Time-related issues

'Time Compression Paradigm' or 'Time-Based Management' (TBM) in SCM has emphasised eliminating the waste in information flow. Eliminating waste in information flow is also considered relevant in agile supply chains (e.g. Mason-Jones & Towill 1999). Time is a key dimension of supply chain performance and should be considered also in information integration. Stalk & Hout (1990) warn about the problems caused by slow information *lead-times*, as information loses value when it ages. Therefore, information lead-time should be compressed so that the information is fresh and meaningful (Stalk & Hout 1990). Information flow does not have the same lead-time constraints as a production process and via IT it is possible to reduce the information transmission lead-time from one end of the chain to the other to zero (Mason-Jones & Towill 1999).

According to Widén-Wulff & Davenport (2005), information sharing can not be considered without taking *timing* into account. Widén-Wulff & Davenport (2005) define timing as a judgment to make a move, triggered by private motives, the demands of the work process or a mixture of both. Timing of information sharing may be of less importance if the information shared is continuously available through an information system or database. If, however, information is shared informally, timing becomes crucial.

2.5 Extent of integration

Three concepts have been used in the literature to describe supply chain integration and its extent: *direction, scope,* and *level* (e.g. van Donk & van der Vaart 2005b). The direction of integration describes whether integration efforts are directed downstream or upstream in the supply chain. The scope of integration refers to the number of supply chain areas (or dimensions) in which co-operation is developed (van Donk & van der Vaart 2005a). The level of integration describes to what extent an integrative activity is developed within a dimension (Frohlich & Westbrook 2001, van Donk & van der Vaart 2005a). The level applies to all the areas of the scope of integration (van Donk & van der Vaart 2005a). This study focuses on the level of integration, but the concepts of direction and scope are described here shortly as well.

2.5.1 Direction of integration

A distinction between upstream and downstream integration has been widely accepted and documented in supply chain management literature (Frohlich & Westbrook 2001, van Donk & van der Vaart 2005b, Tan 2001). External integration has been operationalised in research as integration upstream (e.g. (Sanders & Premus 2005), downstream (Germain & Iyer 2006) or either downstream or upstream integration (Stank *et al.* 2001). Downstream integration refers to integration towards customers and upstream integration describes the integration with suppliers. Fawcett & Magnan (2002) use correspondingly the terms backward integration (with suppliers), forward integration (with customers) and complete forward and backward integration (from supplier's supplier to customer's customer). Another classification on the dimensions of analysing supply chain management or external integration is used by Croom *et al.* (2000) and consists of three categories: dyadic, chain, and network (upstream, downstream, or the total network).

However, there are no clear guidelines in the literature telling how to classify the direction of integration with service providers. If applying the upstream-downstream grouping presented in earlier literature, a distinction for services could be made, for instance, based on whether they are delivered

- before the production at the focal company takes place (e.g. maintenance and repair of the production equipment, transport from suppliers to focal company) referred as integration upstream or
- after the production occurs (such as transport to customers, installation service at customer's facilities, etc.) referred as downstream integration.

But what if we are dealing with a pure service supply chain, where there is no production activities involved at all? There still should be an identifiable focal company, providing the core service or product and orchestrating the other supply chain links. According to Min *et al.* (2005), collaboration is typically 'tailored' towards the customer company and customers also usually initiate and design the collaborative arrangement. This is reflected also in integration and means that despite the direction of integration, the company having the role of a customer company is the focal firm in integration. Bagchi & Skjoett-Larsen (2003) further remind that integration depends on the power, influence, motivation, and eagerness of the prime mover (the focal company) in the supply chain.

In the study by Fawcett & Magnan (2002) concerning supply chain integration, service providers generally had a view on their customer company, but not beyond that of the total supply chain. Thus, the perspective to integration with service providers seems to be more a dyadic one than one with complete or bi-directional network integration.

2.5.2 Scope of integration

The *scope* of integration describes the number of supply chain areas or processes in which co-operation is developed (see e.g. van Donk & van der Vaart 2005b). SCM literature has so far paid attention to integrating purchasing and supply activities or transportation and logistics (Tan 2001). Moreover, product development and marketing have also gained some attention in research (e.g. Cooper *et al.* 1997). Very little attention has been paid to integrating service processes in supply chains.

Four dimensions, on which integrative activities can be developed, have been distinguished by van Donk & van der Vaart (2005b): flow of goods, planning and control, organisation, and flow of information (based on e.g. van Donk 2003, Childerhouse & Towill 2002). Van Donk & van der Vaart (2005b) add product development as the fifth dimension. These suggestions have some similarities with the four interconnected integration layers presented by Fabbe-Costes & Jahre

(2008): integration of flows (material, information, financial), integration of processes and activities, integration of technologies and systems, and integration of actors (structure and organisations). However, van Donk & van der Vaart (2005b) do not identify systems and technologies as a separate dimension, but include them in the information flow dimension. Moreover, they consider processes primarily from the planning and control perspective and consider product development as a separate dimension. The classification by Fabbe-Costes & Jahre (2008) seems to be more general and thus applicable also in service context.

2.5.3 Level of integration

The supply chain integration concept is not monolithic and different levels of integration activities exist (Swink *et al.* 2007). Much of the research in integration has been based on the assumption that integration occurs or develops in distinct stages or levels (e.g. Narasimhan & Kim 2001). Some attempts to identify and analyse levels of integration exist in the literature. Spens (2001) has used five levels of integration to explore process integration in a blood supply network. The levels, defined by Alter (1999), are common culture, common standards, information sharing, coordination, and collaboration. Spekman *et al.* (1998) have used three levels (co-operation, coordination, and collaboration) to describe 'levels of intensity' among trading partners. In both approaches, the first levels are threshold levels of interaction and at the uppermost level the interdependency of processes and/or partners is very high. Bagchi & Skjoett-Larsen (2003) have also described the development of integration in three stages: low, medium, and high integration. Cousins & Menguc (2006) suggest that integration occurs at several levels, beginning with improvements in communication and ultimately leading to improvements in financial and service performance as demonstrated e.g. by Vickery *et al.* (2003). According to Ragatz *et al.* (2002) an organisation is considered to have a high level of integration with its supply chain partner when its information systems are linked with the partner, both parties are able to access accurate and real-time information, and there are effective means of communication across the two parties. Finally, Frohlich & Westbrook (2001) have used the 'arcs' of integration ranging from narrow to broad and from no integration to extensive integration to describe the extent of integration.

Van der Vaart & van Donk (2004) have defined three stages (or levels) of integration: transparency stage, commitment/coordination stage, and integrative planning stage. They can be characterised as follows:

- *The transparency stage*: Supply chain members share some relevant information. The incompatibility of information systems and lack of mutual trust (i.e. fear of misuse of information) constitute major barriers for integration. Information is shared without any form of commitment and supply chain members are independent in their decision-making. 'Local' optimisation of resources occurs.
- *The commitment and coordination stage:* Supply chain members share all relevant information. Trust is an important barrier for integration, as well as the incompatibility of information systems. A mutual commitment exists.
- *The integrative planning stage:* The planning and control of a supply chain (or a part of it) is more or less centralised. The existence of shared resources (e.g. same supplier is supplying to several buyers) forms a major barrier in this stage.

According to van der Vaart & van Donk (2004) these levels are overlapping and especially useful for describing a dyadic relationship in a supply chain. The level of integration does not have to be the same for a whole chain or for all supplier-buyer dyads. A dyad does not necessarily have to start with stage 1 and then move up to stage 3, but instead these stages just describe the level of integration. (van der Vaart & van Donk 2004). The dyadic perspective is also supported by Gimenez & Ventura (2005) who state that there is a need to consider the level of integration in each particular supply chain relationship instead of assigning the global level of integration into a firm. Indeed, one of the limitations in Gimenez & Ventura's (2005) study is that although a relationship perspective to integration is advocated, only the manufacturer's side of integration is covered in the study.

As demonstrated also in this literature review and noted by e.g. Fabbe-Costes & Jahre (2008), a variety of different terms have been used to express the level of integration: level, stage, intensity, capabilities, degree, etc. In fact, even within one single research paper several terms may have been used. For instance, Bagchi & Skjoett-Larsen (2002) employ the terms 'level', 'degree', and 'stage' in their article. In this study, however, the term *level* is used to describe to what extent an integrative activity is developed as defined by Frohlich & Westbrook (2001) and van Donk & van der Vaart (2005a). The idea of van der Vaart & van Donk (2004) including three different integration levels is used in classifying the information

integration levels in this study. The classification of van der Vaart & van Donk (2004) is in line with other views concerning the contents of information integration presented in the literature. According to Bagchi & Skjoett-Larsen (2003) information integration entails *information and knowledge exchange* concerning design and development, process management and planning and control, *technology exchange and adaptation*, and *resource and risk sharing*. Kulp *et al.* (2004) divide information integration practices in two groups: *information exchanges* and *collaborative planning*. Thus, it is suggested, that as the level of integration increases, the supply chain moves towards joint planning and decision making and shared risks and resources.

The categorisation to type 1, 2 and 3 relationships in supply chain presented by Shah *et al.* (2002) has also similarities to the levels of integration defined by van der Vaart and van Donk. Type 1 relationship has a short-term focus and involves limited level of information sharing and some operational coordination. Type 2 and 3 relationships have a more strategic nature and are more long-term and collaborative. They include relationship building, joint development activities, and sharing of cost and capability information. In type 3 relationships other firms' processes are seen as extension of own firm's processes and they are very long-term partnerships. (Shah *et al.* 2002, Narasimhan & Kim 2002). Similar typology of collaborative approaches has been presented by Whipple & Russell (2007). They divide collaboration into *collaborative transaction management* with emphasis on operational issues/tasks, *collaborative event management* involving some tactical/managerial level decision-making and some joint planning, and *collaborative process management* presenting strategic collaboration characterised by knowledge sharing and joint decision making.

Finally, the three-level classification chosen is congruent with Mason-Jones & Towill's (1999) suggestion that developing an integrated supply chain requires integrating the information flow at three levels: strategic, tactical and operational. Also Samaddar *et al.* (2006) have defined four types of inter-organisational information sharing based on the volume of information shared and the strategic importance of the information. The idea is similar to the integration levels, as the volume ranges from low to high and the importance from operational to strategic.

2.5.4 Operationalisation of the levels of integration

The three levels of integration by van der Vaart & van Donk (2004) were operationalised along the six elements of information integration identified and defined in this study. 'Processes and activities' describe the link between information integration and process integration through the extent of process integration and the scope of information sharing in processes. 'Information technology use' relates with the coverage of information systems and technologies and the degree of their integration. 'Information attributes' depict the characteristics of shared information consisting of the form, quality and availability of information. 'Information sharing practices' describe the extent and frequency of information sharing. 'Collaborative foundation' elaborates the shared goals, shared resources, trust, commitment, and joint performance measurement in supply chain relationship, i.e. the relationship issues underpinning collaboration and thus integration. 'Time-related issues' represent the speed and timeliness in information sharing and involve the lead-time and timing in information sharing.

Table 1 presents a summary on the criteria for defining the level of information integration in a supply chain as operationalised in this study. Generally, the levels along each element move from low (1) to high (3) and from mere interaction to higher interdependency between supply chain partners. All the elements are inter-related and developing one of the elements may lead to improvements along other elements. For instance, increasing the level of IT use often contributes to the information attributes by improving the availability and quality of information. Moreover, increased IT use typically shortens the lead-time and improves the timing in information sharing. By assessing the integration level for each integration element as presented in Table 1 a detailed analysis on the current level of integration in a supply chain dyad can be made and development areas toward achieving the desired level of integration recognised.

Table 1. Criteria for defining the levels of information integration.

Element	LEVEL I: Transparency	LEVEL 2: Commitment/coordination	LEVEL 3: Integrative planning
Processes and activities			
Process coverage of information sharing	Information sharing occurs only in a part of a supply chain process	Information sharing occurs in some major processes of supply chain /part of supply chain	Information sharing covers all pertinent process of supply chain / part of supply chain
Degree of process integration	Focus on internal activities, fragmented activities	Internal processes integrated	Supply chain focus, integrated supply chain processes
Information technology use			
Information systems / IT coverage	Some data and information is in the systems, some in other archives/files/sources Information technologies are used to some extent	Most data and information needed is in systems (may be in different systems and not accessible for all) IT used regularly	All data and information needed is in information systems IT is used in information sharing whenever possible
Information systems integration	Each supply chain member has own internal information systems	Partial access to supply chain partner's systems / partial integration of systems	Fully integrated systems in the supply chain
Information attributes			
Information form	Majority of the information is shared informally or as paper-based documents	Part of the information is in systems and database and shared electronically, part is shared informally and as paper-based documents	Majority of the information is in databases and systems and mostly shared electronically
Information quality	There are deficits in accuracy, usefulness, reliability and completeness of the information	Accuracy, usefulness, reliability and completeness of the shared information are acceptable	Accuracy, usefulness, reliability and completeness of the shared information are high
information availability	Only some of the information is available when needed	Most of the information is available when needed	All information is available when needed

Element	LEVEL I: Transparency	LEVEL 2: Commitment/coordination	LEVEL 3: Integrative planning
Information sharing practices			
The coverage of information sharing practices	Pure information and knowledge change (operational)	Technology exchange and adaptation (tactical)	Collaborative planning and sharing of risks and resources (strategic)
The frequency of communication / interaction	Low frequency	Medium frequency	High frequency
Collaborative foundation			
Shared goals	Supply chain members share operational goals	Supply chain members share tactical goals	Supply chain members share strategic goals
Shared resources	Each supply chain member has its own resources in use	Some resource exchange	Resource pooling in supply chain
Trust	Fundamental level of trust exists between supply chain members	Middle level of trust exists between supply chain members	High level of mutual trust exists between supply chain members
Commitment	Short-term co-operation /individual contracts No guarantee for the continuity of the relationship	Medium-term co-operation/ contracts Some expectations of continuity	Long-term partnerships and continuity
Performance measurement	Supply chain members have own performance measured	Some common performance measures in supply chain	Common supply chain performance metrics in use
Time-related issues			
Information lead-time	Slow information lead-time	Moderate information lead-time	Lead-time close to zero. Real-time information sharing
Timing of information sharing	Timing of information sharing is not optimised and could be developed	Timing of information sharing is on an acceptable level	Information accessible real-time Timing is not a problem

2.6 Contextual factors affecting integration

It has been generally recognised in the literature, that SCM practices may be influenced by contextual factors (Li *et al.* 2006). Already Kraljic (1983) suggests in his purchasing-portfolio approach that the need for collaboration and thus integration differs. It can also be derived from the transaction cost theory (e.g. Williamson 1975, Williamson 1985) that different types of relationships create varying information processing requirements (Sanders 2008). Also the contingency theory offers the basic assumption that matching organisational resources with the corresponding environmental context can improve firm's performance. Moreover, integration practices have been considered to be embedded in the context that supports or restricts the use of certain practices (Ho *et al.* 2002). Bagchi & Skjoett-Larsen (2003) have proposed that a high degree of integration is not necessarily desirable in all situations and have suggested applying a contingency approach to supply chain integration. According to Mouritsen *et al.* (2003: 694), 'there is a range of collaboration forms and mechanisms of integration available and the most appropriate ones depend on contextual circumstances'.

Several various sets of contextual factors possibly affecting the integration can be found in the literature. Li & Lin (2006) have stated that information sharing and information quality may be affected by contextual factors that should be addressed in future research. These include the type of industry, firm size, a firm's position in the supply chain, supply chain length, and the type of supply chain (Li & Lin 2006, Li *et al.* 2006). Bagchi & Skjoett-Larsen (2002) have described the situational factors affecting the nature and extent of supply chain integration through a contingency approach. In their approach, competence, market competition, type of product (service), industry maturity, and power/market competition are the factors determining the level of supply chain integration, either high or low. Van Donk & van der Vaart (2004) view the contextual business conditions also through the decoupling point, (made-to-order vs. made-to-stock), time window for delivery, volume-variety characteristics, process type, and order winners. Cagliano *et al.* (2006) indicate in their study on manufacturing supply chain integration that companies in the final stages of supply chain, i.e. closer to the end customer, share more information with their suppliers, suggesting that the company's position in the supply chain affects the information sharing.

Uncertainty has been one of the most important aspects of SCM context and has been widely covered in the literature (van Donk & van der Vaart 2005b). The level of uncertainty in a supply chain has been considered as an important factor to affect the level of integration in supply chains (e.g. Fisher 1997, Christopher & Towill 2002, Lee 2002). Integration is related to reducing uncertainty (Childerhouse & Towill 2003). A high level of uncertainty is a driving force to aim at more integrative practices, but minimal uncertainty in supply chain is not equal to having integration (van Donk & van der Vaart 2005a). There is also empirical evidence that the level of integration is affected by the level of uncertainty experienced in a buyer-supplier link (e.g. Childerhouse & Towill 2002, van Donk & van der Vaart 2004, van Donk & van der Vaart 2005a, Mason-Jones & Towill 1998). Van der Vaart *et al.* (2006) have demonstrated, that under circumstances with a high level of uncertainty in demand or technology, integrative practices are especially helpful in achieving a better performance in a buyer-supplier relationship.

Van Donk & van der Vaart (2005a) state that if both parties in a business-to-business relationship consider their relationship as strategically important and supply chain uncertainty is high, a collaborative relationship with a broad scope and high level of integration are appropriate. Shared network or supply chain resources limit the possibilities for integration (van Donk & van der Vaart 2005a, van der Vaart & van Donk 2004).

Welker *et al.* (2008) make a distinction between complex and simple business conditions and their effect on information sharing in buyer-supplier relationships. Information processing under simple business conditions can be largely standardised and information systems used should be able to support standardised information flows. Shared information will concern product information, price and timing. In case of complex business conditions the products (or services) are partly or even fully customised. External information sharing may involve information on forecasts, product (or service) specifications, and capacities for planning purposes. Due to the uncertainty concerning specifications of products (or services) and timing, it may be necessary to additionally exchange information through direct contacts between the supply chain companies (Welker *et al.* 2008). Welker *et al.* (2008) conclude that simple business conditions are linked to limited information sharing and complex business conditions to greater extent of information sharing. Surprisingly, Welker *et al.* (2008) found no relationship between the business conditions and the use of information systems. In fact, under more complex business conditions external information sharing was conducted

through direct contacts between the parties involved, e.g. phone calls and meetings. They suggest that perhaps information systems in companies are not suitable for the complex business circumstances or the complexity of the activities where information is shared is so multifaceted that only mutual adjustment and direct contact will be adequate to cope with the uncertainties and ambiguities.

The above-mentioned characteristics, however, are typically selected to describe manufacturing supply chains and the set of factors describing uncertainty has to be modified to be used to describe service supply chains. Next, contextual factors relevant to service supply chains are discussed through dividing them to relationship characteristics and service/market characteristics. Other possible contextual factors and the reasons for their exclusion of the model on contextual factors used in this study are discussed. Finally, a model on contextual factors for service supply chains is presented.

2.6.1 Service supply chain relationship characteristics

Power and interdependence

Several studies (e.g. Wong & Boon-itt 2008, Cagliano *et al.* 2006, Wu *et al.* 2004) have indicated that environmental uncertainty is a main trigger to supply chain integration and institutional norms act as a moderating factor for the relationship between environmental uncertainty and supply chain integration. Institutional norms refer to the expectations of behaviour or practice that are acceptable within an institutional environment (e.g. supply chain). A strong supply chain member may apply institutional norms to achieve higher level of organisational integration (e.g. DiMaggio & Powell 1983). Institutional norms can also be observed from the perspective of use of power to influence the practices of other parties in the supply chain. A firm's power (or dominance) in a supply chain can be defined as its potential for influence on other chain member's attitudes and behaviour (Bagchi & Skjoett-Larsen 2002). Power can be symmetrical, referring to power balance between parties in a relationship, or asymmetrical, meaning a power imbalance (Dwyer & Walker 1981). A strong supply chain buyer could, for instance, use its purchasing power to convince its suppliers to install information systems that connect to the company (Wong & Boon-itt 2008). Also van der Vaart & van Donk (2004) state that the power regime in a supply chain can either limit

the information integration or enable removing some barriers of integration. The power aspect plays an important role in division of capacity and priority rules by suppliers. The more powerful buyers can claim their part of the suppliers' capacity (production or services). (e.g. van der Vaart & van Donk 2004). Scheer & Stern (1992) state that inter-firm power can have a positive role in promoting effective coordination in a supply chain relationship for both the powerful and the relatively dependent chain partner. Also Zhao *et al.* (2008) have shown that power can increase the relationship commitment and thus facilitate integration. According to Wong & Boon-itt (2008) institutional norms can particularly enhance the level of integration when the level of environmental uncertainty is high.

Level of interdependence has been shown to affect the selection of coordination mechanisms in supply chains (Xu & Beamon 2006). Wu *et al.* (2004) have also examined the effect of dependence (i.e. the extent to which a trade partner provides important and critical resources for which there are few alternative sources of supply (Skarmeas & Katsikeas 2001)) on integration. Higher dependence seems to lead to higher commitment and through this to higher level of integration. In service supply chain this kind of dependence can be created through the complexity of the services, as then the service provider is more difficult to replace. Also a high buyer focus might mean that replacing the service provider may be more complicated, as to achieve the same volume and variety of services from other providers the buying company might be forced to use several different service providers. Level of interdependence can also be defined as the degree of one organisation's potential to influence on the other organisation's beliefs, attitudes, and behaviours (Heide 1994, Frazier 1999). According to Sheu *et al.* (2006), interdependence exists when one party does not entirely control supply chain operations. Three aspects of dependence can be identified: the percentage of a firm's business conducted with the other firm, the commitment of a firm to the other firm strategically, and the difficulty in effort and cost faced if either firm decides to exit the relationship (El-Ansary & Stern 1972). Mohr & Nevin (1990) have demonstrated the implications interdependence has on communication between channel members. Huber & Daft (1987) have shown that the greater the interdependence is, the greater is the frequency of communication between companies. Sheu *et al.* (2006) have used a scale ranging from low, through medium to high to rate the levels of interdependence in their study dealing with supplier-retailer relationships. Samaddar *et al.* (2006) state, based on the information and communications theory, that highly interdependent

relationships require a richer form of communication, i.e. sharing strategic level information, which also supports the idea of increased interdependence leading to a higher level of integration.

It seems that the existence of power as such does not necessitate or lead to a certain level of integration. However, power may play a substantial role in the formation and maintenance of supply chain relationships that drive supply chain integration and thus affect the supply chain performance (Maloni & Benton 2000). The concepts of power and interdependence are interrelated. In situations with low level of interdependence between a more dominant partner and another firm a low level of integration is expected (see e.g. Bagchi & Skjoett-Larsen 2002). The more powerful partner usually dictates the nature and extent of a supply chain relationship, and supply chain integration flourishes if the more powerful partner is willing and eager for a closer partnership (Bagchi & Skjoett-Larsen 2002). Bagchi & Skjoett-Larsen (2002) suggest that, for instance, a competitive environment might make the more powerful company aim for a high level of integration with its supply chain partners. Cox (2001) states that integrative SCM approaches work best in supply chain structures with extended buyer dominance (power) or extended buyer and supplier interdependence.

Type of resources in supply chain

Business conditions affect the level of focus in a supply chain dyad (van Donk & van der Vaart 2005b). According to Cagliano *et al.* (2006) the level of information sharing is negatively influenced by the number of suppliers, meaning that firms with larger supply base exchange less information, compared to the ones with fewer suppliers. Level of focus, i.e. the type of supply chain resources, either enables or restricts the possibilities for integrative practices in the dyad and is thus important (van Donk & van der Vaart 2005b). A shared resource is a common capacity used for different supply chains or networks (e.g. a supplier used by different buyers). In case of shared supplier resources, orders from different buyers are competing for the same resources. Shared resources increase the complexity in planning and control, especially, when the capacity of these resources is scarce. (van der Vaart & van Donk 2004). Counterpoint to shared resource is the buyer focus, which means that resources are singled out to serve one single buyer (van der Vaart & van Donk 2004). Buyer focus especially fits to a supply chain relationship with high uncertainty in demand (regarding volume and mix, and/or lead-time) (Griffiths *et al.* 2000). In supply chain dyads with high

uncertainty closer integration is needed, but shared resources make it difficult to attain higher levels of integration (van Donk & van der Vaart 2005a). Buyer focus is thus seen as a valuable concept for improving the level of integration in a supply chain relationship (van der Vaart & van Donk 2004).

Closeness of customer relationship

Bask (2001) has utilised the closeness of customer relationship when describing and classifying logistics services (or service providers). Also according to Goffin *et al.* (2006), closeness has been widely identified as an important characteristic of relationships. The customer relationship between a service buyer and a service provider can be categorised to loose, moderate or close. (see Bask 2001, Mäkelin & Vepsäläinen 1990). For a service relationship to be efficient, Bask (2001) combines services with low degree of complexity (routine services) with a loose customer relationship, services with medium complexity (standard services) with a moderate closeness in the customer relationship, and customised services involving high degree of complexity with a close customer relationship.

2.6.2 The service/market characteristics

Degree of complexity and volume uncertainty in services

Uncertainty regarding demand has been connected with the integration levels in earlier research. Van Donk & van der Vaart (2001) have shown that increasing uncertainty in volume, mix, and specification is an important driving force to move towards the level 2 and 3 integration. Van Donk & van der Vaart (2005a) define four different situations regarding the uncertainty in volume and mix/specification:

- Low volume uncertainty, low mix/specification uncertainty
- High volume uncertainty, low mix/specification uncertainty
- Low volume uncertainty, high mix/specification uncertainty
- High volume uncertainty, high mix/specification uncertainty.

Van Donk & van der Vaart (2005a) generally state that higher levels of uncertainty in both specification/mix and volume necessitate closer co-operation and integration in supply chain links. Uncertainty in service supply chain context

can similarly be defined through the level of uncertainty regarding the volume and mix/specification of services. The variety or uncertainty in demand of services shows in the form of *scope of the services provided (service mix)* or *the degree of complexity (specification) of the services provided*. In other words, it describes what services need to be delivered. Generally, with increased variety comes also greater complexity (Aitken *et al.* 2005). Bask (2001) has used the complexity of services as a factor in describing and classifying logistics services. The complexity of services (i.e. the uncertainty in service mix/specification) increases when the degree of customisation increases and can be considered simple, medium or complex. Kellogg & Nie (1995) have also considered the degree of customisation in services by dividing it into four categories: full, considerable, limited, and little or no customisation. Thus, they have had the same principle, but one additional category to describe it.

Typically, a higher level of variety leads to a lower volume per variant (Aitken *et al.* 2005). The volume in service operations refers to *how much resource capacity needs to be planned or reserved* to be able to deliver the services. Services are delivered based on orders from the customers as they can not be inventoried. This leads to a higher uncertainty in demand compared to manufacturing operations. In manufacturing supply chains, an analogous concept to volume uncertainty, 'variability', has been used to describe the 'spikiness' or unpredictability of demand and the need for considering it when choosing an appropriate supply chain strategy has been shown (Aitken *et al.* 2005).

Order winning criteria

Hill (1985, 1989) has initially conceptualised the order winners and order qualifiers. Order winners are the attributes, on which the customer bases the decision to purchase the product or service (Hill 1989). The principle behind the order winners is that competitive priorities are concerned with the importance that companies attach to various dimensions of performance, e.g. cost, quality, time and flexibility (Safizadeh *et al.* 2000). Originally, the order winners were deployed in converting market requirements into manufacturing goals and to be applied in manufacturing operations. However, Hill (1989) argues that his ideas are also applicable to service operations, although no specific examples of applying them in services are offered. Support for existence of order winners in service operations, called 'service winners' (Rosen & Karwan 1994) or 'customer/account winning criteria' (Roth & van der Velde 1991) has also been

presented. Moreover, Hill's (1989) ideas have been applied in service operations for instance by Staughton & Williams (1994) in their service template. Furthermore, Hill & Brown (2007) utilise the order winners in a strategic profiling framework for service organisations.

It seems that the order winners in services have been employed in determining the internal strategic fit in service operations, but not in analysing choices in external relationships. However, the applicability of order winners also for supply chain design has been supported by e.g. Appelqvist (2003). Moreover, van der Vaart & van Donk (2004) have presented a continuum for order winners and linked it with the level of integration. Their suggestion is, that cost as the order winner necessitates and enables a low level of integration. The other extreme is flexibility as the order winner leading to high level of integration. Van der Vaart & van Donk (2004) have validated their idea in manufacturing supply chain dyads. (van der Vaart & van Donk 2004). The order winner, when selecting service providers, is probably more often the quality or flexibility of services than merely costs (or price). This, however, depends also on the nature of the services, i.e. the degree complexity of the services. Routine services may be purchased merely based on the price (cost).

2.6.3 Other contextual factors

Service process

The idea of contextual variables affecting the practices and performance has also been presented in service management literature. For instance, de Búrca *et al.* (2006) find identifying the circumstances intervening service practices-service performance relationship important and suggest considering the context of how service is provided and how service organisations position or classify themselves. The service process has been described along several characteristics, for instance, by Kellogg & Nie (1995) through the degree of customer influence ranging from expert service to service factory. Some other service operations frameworks have also covered different aspects of service process. Customer contact model (Chase 1981) deals with the degree of customer contact in contrast to production efficiency and sales opportunities. Schmenner's (1986) service process matrix includes the degree of labour intensity, degree of interaction and degree of customisation in services. Other service dimensions have been equipment vs.

people focus in services, value added in back office vs. front office, and product vs. process focus of services (Silvestro *et al.* 1992). Hence, it seems that the service management/marketing literature is stuffed with classifications of *consumer* services, which, according to Wynstra *et al.* (2006) are not very helpful in understanding buyer-supplier interaction in *business services*. As the service process typologies are better applicable for consumer services than business services, these aspects (except for the degree of customisation/complexity discussed earlier) are left outside the model on contextual factors in this study.

Johansson & Olhager (2004) have presented a model for industrial services to match the service offering and service process. Their model entails a wide variety of factors; i.e. the order winning criteria and degree of service customisation that are also included in this study. This framework, however aims at matching the service offering and process of a company, and not at developing the management of service-related supply chain relationships. Thus, other factors in the Johansson & Olhager (2004) model were left out of this study. No classification to indicate the effects of these aspects in business services that could clearly be linked to integration levels was found in the extant literature.

Finally, other models dealing with customer service as the basis to look for situational typologies or differentiation possibilities have been presented focusing, for instance, on physical distribution service quality in internet retail (Xing & Grant 2006) or behavioural aspects of customer service (Pisharodi & Langley 1990). Pisharodi & Langley (1990) base their process model of customer service on the fact that different observers, such as sellers and buyers, often have different perceptions about a service. As in this study the contextual setting was rather approached from a dyadic perspective through a common view of the companies in the dyad, and the Pisharodi & Langley model would rather contribute to the developing the evaluation and measuring of the integration outcomes, it is rather considered a topic for further research and not integral to this study. Xing & Grant (2006) are, in their framework, focusing on services involving a physical product and the outcomes of the service related to it, and thus their model, as such, is not applicable in this study either.

Behavioural factors

Wu *et al.* (2004) have shown that a group of behavioural determinants affect the commitment in supply chain relationship. Higher degree of trust, power, continuity, and communication lead to higher commitment and thus higher level

of integration in supply chain relationship. Continuity is the perception of the bilateral expectation of future interaction (Heide & John 1990). The perception of continuity will have a corresponding level of commitment and long-term relationships are more probable to promote strategic level integration (Wu *et al.* 2004). Moreover, communication fosters confidence in the continuity of the relationship (Anderson & Narus 1990).

According to Grant (2005), the customers in dyadic exchanges with their suppliers tend to pay more attention on transactional dimensions (e.g. availability, timeliness, and price) than the relationship dimensions, such as trust, commitment, and integrity. This certainly hinders the formation of close, long-term relationships between customers and suppliers. However, especially in the service context, the increased complexity of the (service) offering, as described earlier in this chapter, may act as a trigger towards a close relationship, thus promoting collaboration in the dyad.

In this study, many of these factors (e.g. trust, commitment) have already been included in the 'collaborative foundation' element of information integration, and are thus not included in the contextual factors to avoid overlap of the concepts. Moreover, communication, in this study is rather seen a means of integration and already incorporated under the element of 'Information sharing practices', hence not included in the contextual framework either.

Firm size

Firm size affects the extent of information integration. In general, small suppliers or customers will typically not be the partners for integration for larger and more powerful organisations in a supply chain (Bates & Slack 1998). SMEs' (small and medium-sized enterprises) structure, owner's attitude, resource poverty, limited infrastructure, limited knowledge, and limited expertise with information systems may affect their ability to integrate and plan effectively (e.g. Blili & Raymond 1993, Ballantine *et al.* 1998). Firm size also influences the level of resources available for investment in information technologies and associated training and education (Iacovou *et al.* 1995). Smaller businesses are often less aware of the potential benefits of IT. Koh & Maguire (2004) have also stated that information integration applications are often less appropriate to SMEs who typically integrate tacit and cultural knowledge rather than explicit knowledge.

Highly routinised supply chains highly influenced by a focal firm are more likely to integrate information in the chain (Harland *et al.* 2007). Kim (2006) has

indicated that efficient supply chain integration may play a more critical role for gaining sustainable performance improvement in small companies compared to large companies. However, from the research so far it could not be concluded that size as such would lead to or necessitate a certain level of information integration. In fact, on the contrary to the statements that small size restricts the integration possibilities, van Donk & van der Vaart (2004) demonstrate in their case study that highly integrated practices are possible in a buyer-supplier relationship even if the supplier is small. Therefore, size is not included in the model on contextual factors affecting the integration level in service supply chain. Nevertheless, the size will be discussed in this research when presenting ideas for developing the integration. Above all, when small companies are involved in supply chains, the larger companies have a role in building integration bridges (e.g. training, education, and investment support related to information technologies) to the small companies critical to their supply chain (Harland *et al.* 2007).

2.6.4 A model on contextual factors in service supply chain

Van der Vaart *et al.* (2006) suggest that the type and level of integrative practices should fit with the type of business conditions in a supply chain. When combining the integration levels (presented by van der Vaart & van Donk (2004)) with the relevant characteristics of a service supply chain (contextual setting), a scheme presenting the expected interrelationships between the characteristics and level of integration can be presented. Developing the scheme is based on similar illustration for manufacturing supply chains by van der Vaart & van Donk (2004). Some more empirical support for this type of model was presented by Welker *et al.* (2008) who demonstrated the connection between low complexity of business and low level of information sharing (integration) and complex business conditions and high level of integration. However, Welker *et al.* (2008) considered the relationship between business conditions and level of integration only in terms of type of information shared, whereas this study applies a more holistic framework with several additional elements to be covered (i.e. the six elements of information integration). Similarly, van der Vaart & van Donk (2004) examined in their study the context and integrative activities emphasising the planning and coordination in supply chain, thus having a narrower view on integration than in this study.

The propositions regarding the contextual factors affecting the level of integration in service supply chain dyads are summarised in Figure 4. The

framework in Figure 4 serves as a basis for discussion on the level of integration achievable, favourable, and needed under different circumstances with respect to characteristics of the services and the relationship in a service supply chain dyad.

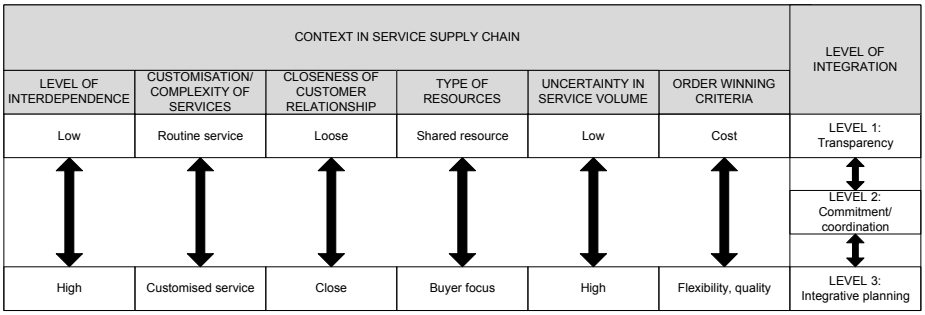

Fig. 4. The effect of contextual factors on the level of information integration in service supply chain.

A service provider may supply services with varying degrees of complexity to different customer companies. Therefore, the dyadic perspective taken in this model to view the contextual factors in focal company-service provider relationship seems reasonable. Earlier studies have explored the context in buyer-supplier relationships from the perspective of the buyer company or from the point of view of the suppliers (van der Vaart *et al.* 2006, van Donk & van der Vaart 2004). The framework in this study is more comprehensive and truly dyadic in the sense that it includes both the service provider and the company buying the services when examining the context.

One limitation of the model on contextual factors is that one contextual factor might suggest a higher level of integration, whereas another is in favour of low level of integration. In this study the integration level suggested by the model has been determined as the aggregate level of integration based on the average of the levels of integration suggested by the six distinct contextual factors. It also has to be noted, that the division to contextual factors and elements used in determining the level of integration is not clear in the literature. Some contextual factors may rather be seen as decision variables and, for instance, could be dealt as a part of the collaborative foundation element of this study. These kind of problems have been identified also by Bagchi & Skjoett-Larsen (2002) in their contingency approach to integration.

Finally, the variables in the presented model are dynamic, and may change over time. For instance, Aitken *et al.* (2005) point out that order winning criteria are dynamic, and change in them may also create a need to revise the supply chain strategy accordingly over time. Similarly, changes in the contextual factors presented in Figure 4 may necessitate adjusting the level of integration in a supply chain dyad correspondingly.

2.7 Information integration and supply chain performance

2.7.1 Measuring and managing supply chain performance

Control of processes in a supply chain is vital in improving performance and can be achieved at least partly through measurement (Gunasekaran *et al.* 2004). According to Brewer & Speh (2000) the four major goals in SCM are waste reduction, time compression, flexible response, and (unit) cost reduction. It can be concluded that supply chain performance is a complex concept due to the multiple goals it has. Consequently, there is also a mixture of approaches and measures in the literature to explain the performance effects of supply chain integration ranging from strategic firm performance to a mixture of operational and financial measures (see e.g. Fabbe-Costes & Jahre 2007). There seems to be no consensus in integration research on how performance in supply chain should be measured (Fabbe-Costes & Jahre 2007).

Generally, performance measures can be categorised into *quality, time, flexibility,* and *cost* (e.g. Neely *et al.* 1995). A simple approach to categorise supply chain performance measures is to divide them into *qualitative-based* measures, which may not be directly described numerically and *quantitative-based* measures, which may be directly depicted numerically (Beamon 1998). Gunasekaran *et al.* (2001) have also extensively examined supply chain metrics and divided them to financial and non-financial measures on *strategic, tactical* and *operational* level. The categorisation into operational, tactical and strategic levels is based on the time horizon for activities and the pertinence of decisions to and influence of different levels of management (from short term to long term, from low to top level management).

Supply chain models have predominantly used cost or a combination of cost and customer responsiveness as performance measures (Beamon 1999). Beamon (1999), however, argues that supply chain performance should be measured along

three different types of performance: *resources, output,* and *flexibility*. Resource measures include, for instance, inventory levels, personnel requirements, equipment utilisation, energy usage and cost. Output measures comprise of customer responsiveness, quality, and the quantity of final product produced. However, the operationalisation of these measures varies as, for instance, Sezen (2008) has used also time- and cost-related measures as output measures. To measure flexibility, four types of flexibility should be considered: volume flexibility, delivery flexibility, mix flexibility, and new product flexibility. (Beamon 1999).

Improvements in time-based performance have been sought and time-based strategies have been particularly applied in the automotive industry (e.g. Dröge *et al.* 2004). Indicators such as 'time-to-market', 'time-to-product' and responsiveness have been used to describe time-based performance effects of integration (Dröge *et al.* 2004). Also the effects of time-based performance to overall firm performance have been examined. For instance, Dröge *et al.* (2004) have demonstrated that internal and external integration affect overall firm performance indirectly through their impact on one or more time-based performance outcomes. But Dröge *et al.* (2004) admit that along time-based performance outcomes integrative practices can also lead to other performance improvements, such as quality/reliability, cost, and flexibility performance. This advocates considering at least four performance aspects (time, cost, quality/reliability, flexibility) in supply chain relationships. The general performance aspects seem to be same even in service context. For instance, Lange *et al.* (2007) have developed a performance measurement system for measuring the essential interactions between industrial service providers and their customers. The systems covers the service effectiveness/reliability (quality), service responsiveness (time), service flexibility, service assets (cost), and service efficiency/productivity (time and cost-related measures) (Lange *et al.* 2007).

Ho *et al.* (2002) suggest tying the performance measures of supply chain to the supply chain strategy, that is to say the competitive priorities pursued by the supply chain members collectively. The competitive priorities to be chosen include cost, quality, flexibility, and delivery. It seems that the notion of *delivery* is used instead of the time category. However, the measures included in the delivery category seem to reflect time-based measures, e.g. in terms of lead time, cycle time, and frequency (see e.g. Ho *et al.* 2002, Gunasekaran *et al.* 2001). When measuring the performance in supply chain, one can generally choose to focus on the relationship with one important supply chain partner, the

relationships with key supply chain partners, or the relationships with all partners. (van der Vaart & van Donk 2008). However, very few empirical studies have taken a dyadic perspective on performance management in supply chain processes (e.g. Forslund & Jonsson 2007).

The general aspects of performance measurement (quality, cost, time, and flexibility) have multiple dimensions, and the suitable measures should be chosen based on the supply chain process(es) to be measured. Gunasekaran *et al.* (2004) state, that a performance measurement program for a supply chain should cover the important aspects of performance in any supply chain link and tailor them to the varying needs of supply chain participants. Lapide (2000) argues that in order to be meaningful, supply chain metrics must be common among the chain members.

Performance measurement in supply chains has been criticised for the lack of balanced approach that could be achieved by combining financial and non-financial performance measures and using only a limited number of good metrics (Gunasekaran *et al.* 2001, Maskell 1991). Moreover, the lack of division into metrics at strategic, tactical, and operational level has been considered a deficit in performance measurement (Gunasekaran *et al.* 2001). According to Neely (2005), current challenges in performance measurement research include:

- How to deploy performance management instead of performance measurement,
- how to measure performance across networks rather than within organisations,
- how to measure tangible and intangible assets,
- how to develop dynamic measurement systems, and
- how to enhance the flexibility of measurement systems to deal with organisational changes.

2.7.2 Performance effects of integration

There is growing empirical evidence suggesting that supply chain integration is associated with greater potential benefits (Devaraj *et al.* 2007). The connection between integration and performance has been studied and authenticated e.g. by Armistead & Mapes (1993), Frohlich & Westbrook (2001), Narasimhan & Jayaram (1998), Frohlich (2002), Narasimhan & Kim (2002), Tan (2002), Rosenzweig *et al.* (2003), Zailani & Rajagopal (2005), and Swink *et al.* (2007). Improvement in supply chain performance could mean, for instance, increased

sales, cost savings, increased market share, inventory reduction, improved quality, accelerated delivery times, and improved customer service. According to Armistead & Mapes (1993), supply chain integration improves quality and operating costs. Narasimhan & Jayaram (1998) indicate the effects of integration on customer responsiveness and manufacturing performance. Devaraj *et al.* (2007) show that supplier integration positively affects operational performance and has the greatest impact on delivery timing, costs, and quality. Swink *et al.* (2007) have shown that strategic supplier and customer integration have direct effect on market performance and customer satisfaction. Swink *et al.* (2007) also suggest new knowledge creation, establishment of cooperative relationships and practices, and reduced complexity as main benefits of strategic supplier and customer integration. Strategic supply chain integration also results in more efficient problem solving by facilitating cooperation, joint work, and the creation of problem solving routines (e.g. Frohlich & Westbrook 2001, Flynn & Flynn 1999).

Frohlich (2002) indicates that information sharing in supply chain leads to closer integration, which again is linked to improvements in productivity, customer service and overall market place performance. Rich internal and external communication of pertinent information and knowledge leads to better identification of value-adding and non-value-adding activities and thus to better opportunities for waste reduction (Rosenzweig *et al.* 2003). Li *et al.* (2006) have examined the effects of inter-organisational information sharing on supply chain performance and state that various information sharing schemes consistently improve supply chain performance when the demand is relatively stable. In case of volatile market conditions, information sharing that combines more than one type of information being shared leads to better performance results.

However, according to Fabbe-Costes & Jahre (2008), there are also studies having ambivalent results concerning the link between integration and supply chain performance. Surprisingly most of them still support the idea that 'the more integration, the better performance' (Fabbe-Costes & Jahre 2008). The unequivocalness of the performance effects of supply chain and information integration have also been questioned recently (e.g. Bask & Juga 2001, Das *et al.* 2006). The idea of developing integration only to the extent to which it is necessary is not totally new. Also the proponents of the information processing view (Galbraith 1974) emphasise that a fit should exist between the information processing needs and the information processing capabilities not only within an organisation but also in inter-organisational interactions (e.g. Premkumar *et al.* 2003).

Some studies have also failed to show the relationship between integration and performance (e.g. Vickery *et al.* 2003). One reason for this, suggested by van der Vaart & van Donk (2008), might be the attempt to relate the level of supply chain integration to the overall performance of the focal company. Van der Vaart & van Donk (2008) state that if the extent of integration is measured in one or a small number of a firm's relationships, it will be especially difficult to establish a relationship between integration and the overall firm performance. Instead, it would be reasonable to measure performance in terms of the aims of the integration efforts with respect to the particular relationship. (van der Vaart & van Donk 2008). Devaraj *et al.* (2007) further add, that the benefits of integration should first be translated into operational capabilities (e.g. product quality, delivery reliability, process flexibility, and cost, which then mediate the relationship between integration and higher level business performance measures (e.g. sales growth, customer satisfaction). It has also been advocated that the performance benefits of integration are greater when the level of integration is high. For instance, Zailani & Rajagopal (2005) concluded in their study that the greatest degree of supply chain integration was strongly associated with higher-level performance.

Integration has also been suggested to potentially have negative effects to supply chain performance regarding the innovation and agility in supply chains (Fabbe-Costes & Jahre 2008). Integration requires sharing of sensitive information and creating unique investments, and involves thus risks. Also Swink *et al.* (2007) note that integration activities are not cost-free as gathering and assimilating data form external partners requires personal time, communication media and information systems. According to Das *et al.* (2006), indiscriminate supplier integration can lead to performance degradation. For instance, Swink *et al.* (2007) note that suppliers may be less motivated to provide high levels of performance if they feel that their business interests are secured. Moreover, a highly integrated firm may be less open to opportunities for other new or previously unknown potential supply chain partners or may be exposed to switching costs which hinders seizing the new opportunities (e.g. Swink *et al.* 2007). Integration may hinder learning and assimilation of external knowledge as it limits the points of contacts with the external environments and ties supply chain actors in to set organisational routines that resist change (Sorenson 2003). In research concerning information sharing, for instance, Kaipia & Hartiala (2006) have noted that the value of information sharing can be defined as the benefits derived from information sharing minus the associated costs. Thus, along the

benefits of information sharing the costs related to information sharing and investing in information technology should be considered. This idea is in line with the proposition of Das *et al.* (2006) that a balanced approach to integration should be taken and a mid-range position, i.e. the ideal profile of integration investments that synergise for maximum performance, exists.

Fabbe-Costes & Jahre (2007) sum up, that there are actually very few research papers containing *empirical* studies on the relationship between integration and supply chain performance. Sanders (2008) further points out that most of the studies examining integration and performance have focused on integration from the perspective of focal firm (buying firm) and cover its impact on a narrow range of performance measures. Fabbe-Costes & Jahre (2008) also support this view by stating that when examining the link between supply chain integration and performance, only few research papers actually include performance of other members of the supply chain besides the focal company and thus fail to cover the substantive supply chain performance. Thus, other perspectives (e.g. suppliers' or customers' point of view) and a broader set of performance benefits (both operational and strategic) should be covered in research.

2.7.3 Facilitating integration and performance

SCM improvement is generally implemented through four means: redesigning the products (services) and processes in supply chain, more effectively leveraging the human knowledge base, continuously improving the management of supply chain information flows, and monitoring the external market place to ensure there are no threats or substitutes for the product (or service) (Brewer & Speh 2000). Also several approaches to specifically develop integration and its performance effects in supply chain exist. Kahn & Mentzer (1996) view facilitating integration from the perspective of interaction and collaboration. Interaction is tangible and easier to monitor and can be stimulated through efforts encouraging verbal (face-to-face meetings, phone calls, video conferencing) and written information flow (e.g. reports, memoranda). In stimulating interaction the emphasis is more on tactical level and on bringing structure to the information flow. Activities implemented for stimulating collaboration are typically intangible, less easy to monitor and regulate, necessitate joint efforts to be maintained, and represent a higher level of interdependency. Efforts to facilitate collaboration include programmes, training, or working groups that are aimed at, for instance, teamwork, achieving collective

goals, establishing mutual understanding, and sharing ideas and resources. (Kahn & Mentzer 1996).

Chopra & Meindl (2001) identify actions that help in achieving coordination in a supply chain. Among these are aligning the goals and incentives, improving information accuracy, and building partnerships and trust. According to Das *et al.* (2006) integration can be achieved through technological resources (information technologies) or knowledge generating resources (e.g. cross-functional teams, collective problem solving). Das *et al.* (2006) further propose that is not the isolated integration practices that matter, but rather the performance synergies gained through specific sets of integration practices.

Socialisation acts as a control mechanism to facilitate knowledge exchange within and between firms (Chalos & O'Connor 2004). Socialisation refers to the level of interaction between, and communication of, various actors within and between firms and leads to the building of personal familiarity, improved communication and problem solving (Gupta & Govindarajan 2000). Nonaka & Takeuchi (1995) also refer to socialisation as 'tacit to tacit communication' in their knowledge creation model. Examples of socialisation mechanisms in supply chains are inter-organisational teams, joint workshops, on-site visits, team building exercises, supplier conferences, exchange of personnel across projects, and task rotation or rotation of individuals between organisations (e.g. Cousins & Menguc 2006). Kumar & Seth (1998) have suggested that frequent rotation of individuals between organisations can lead to enhanced coordination, communication, and improved performance of the organisations involved. Furthermore, focusing on this kind of exchange through socialisation, performance can be improved as firms begin to understand how each other works. Socialisation forms bonds and ties that facilitate the exchange of information and ideas and assist in building a culture of mutual commitment between the firms (e.g. Cousins & Menguc 2006). According to Cousins & Menguc (2006), communication should be established using both formal and informal links. They found out in their study involving companies from various industries, that supply chain socialisation affects positively supplier communication and supplier operational performance. Moreover, socialisation has a positive impact on the buyer's perception of supplier's contractual performance.

Patnayakuni *et al.* (2006) suggest that tangible and intangible resources invested in a supply chain relationship enable integration of information flows. In particular, both formal and informal interaction routines that take time and effort to develop facilitate the integration of information flows. Investments in relation-

specific assets and long-term orientation in the supply chain relationship allow the development of this kind of routines. (Patnayakuni *et al.* 2006).

Pagell (2004) states in his model for internal supply chain integration that communication (informal and formal), measurement and reward systems, job rotation, and cross-functional teams affect the level of integration and thus performance. Moreover, organisational structure and culture affect communication and measurement and facility layout affects communication by means of proximity, which is a key driver of communication. (Pagell 2004).

According to Mentzer *et al.* (2000), partners in a strategic relationship reach agreement on broader performance measures than partners in operational partnership. Measures in strategic partnership include measures of the total system, whereas measures in operational partnering focus on the impact on each firm's individual performance (Mentzer *et al.* 2000). Analogously, it can be expected, that when the integration in supply chain moves from level 1 to level 3, the scope of performance management expands from merely operational to strategic level.

Processes and activities

Business process management tools are not bound by company limits and can be applied to supply chains to form a holistic view of supply chain as a single organisation (see e.g. McAdam & McCormack 2001). Modelling and analysing the supply chain service processes and activities in which information is shared will help in highlighting opportunities for improvements through identification and removal of waste and inefficiency, and implementing improvements through a combination of IT and good working practices (e.g. Gunasekaran & Nath 1997). According to Gunasekaran & Nath (1997), more traditional techniques, such as Ishikawa-diagrams and process flow charting (which have also been used in the empirical part of this study), proved to be useful support tools for process re-engineering activities. Process improvement should be a continuous activity following the 'plan, do, check, act' cycle (by Deming 1993) (McAdam & McCormack 2001).

Utilising process improvement practices (e.g. concurrent engineering, standardisation, and value analysis) has been demonstrated to significantly affect time-based performance in supply chain. Moreover, *jointly* deploying process improvement practices and information-intensive IT infrastructures has been shown to affect time-based performance. (Jayaram *et al.* 2000). McAdam &

McCormack (2001) also suggest placement of employees in customer and/or supplier companies to enable formal and informal communication between supply chain members in the processes. It has to be kept in mind, that service processes can seldom be completely standardised, as they are continuously transforming to adapt to new situations (e.g. Piispa 2007).

Information technology use

Studies dealing with the performance effects of IT use in supply chain have been made concerning special technologies (e.g. Mukhopadhyay & Kekre 2002) or IT in general (e.g. Sanders 2008). Most studies represent the perspective of focal firm (buyer) and only a few reflect the view of suppliers (e.g. Sanders 2008, Mukhopadhyay & Kekre 2002, Subramani 2004). IT can reduce the probability of rework and delay, lower costs (e.g. order processing), and simplify processes. IT can also create additional revenues for the supplier, as establishing the electronic link by the focal firm often leads to buying increased volumes from the supplier. (Mukhopadhyay & Kekre 2002). Effective application of IT in integrating supply chain activities reduces the complexity in the chain (Power 2005). IT lowers the cost and improves the availability of information resources and thus allows easy linkages between partners and eliminates information-related time delays in supply chains (e.g. Handfield & Nichols 1999). Harmonised information systems between supply chain partners create a timely, relevant, and high-quality information flow, leading to elimination of unnecessary activities and enhanced delivery of product (service) to customer (e.g. Brewer & Speh 2000). Moreover, Sanders (2005) confirms that IT alignment in buyer-supplier relationships impacts also the supplier firm performance (operational and strategic) both directly and indirectly through facilitating inter-firm integration.

IT can help to realise dramatic returns through efficiency improvements, better asset utilisation, faster time-to-market, reduction in total order fulfilment times, improvements in customer service and responsiveness, penetrating new markets, a higher return on assets, and higher shareholder value (e.g. Lee & Whang 2001). IT can also facilitate collaborative planning among supply chain partners (Gunasekaran & Ngai 2004). Trkman *et al.* (2007) view new information technology and inter-organisational information systems as enablers for process and organisational changes. The positive effects of information technology (IT) on business process improvement have been shown in several other studies (e.g. Bhatt 2000, Mukhopadhyay *et al.* 1995, Mirani & Lederer 1998). The benefits of

IT include improvements in customer service, efficiency, information quality, and agility (Auramo *et al.* 2005). Bhatt (2000) has demonstrated that IS integration (data integration) is an imperative enabler for process improvement and customer focus.

Traditional supply chain information systems have suffered from restrictions in the connectability of the systems. Complex and tight integration of IT systems of supply chain partners is, however, not a necessity. Bartlett *et al.* (2007) suggest leveraging an internet-based platform to facilitate information exchange between partners. Nowadays, also new technologies to arrange the interoperability between separate information systems in supply chains cost-effectively have been introduced. Examples of these are agent technologies applied e.g. in Iskanius (2006) and semantic technologies (Pollock & Hodgson 2004). IT acts as an enabler for collaboration and information sharing; IT has been shown to affect performance both directly and through its positive impact on collaboration (Sanders & Premus 2005).

Kivijärvi & Saarinen (1995) note that investments in information systems will only pay off in the long term, because of the long learning and development period needed to fully exploit them. The approach taken by Shah *et al.* (2002) to align the stage of supply chain coordination and information system capabilities suggests that lack of information system (IS) capability to meet the needs of a supply chain causes inefficiency in the timeliness and availability of information. On the other hand, if IS capabilities exceed the needs of the supply chain, there is an opportunity cost of over-investment in IT. Shah *et al.* (2002) further add that the average gain in performance for companies that have aligned the IS integration and coordination stage of supply chain is remarkably greater compared to the firms in which a mismatch between coordination stage and IS integration exists.

IT use can lead to two collective goods: connectivity and communality (Monge *et al.* 1998). Connectivity refers to the possibility of parties involved to communicate directly with one another. Communality refers to the availability of a generally accessible collection of information. (Monge *et al.* 1998). IT can have the important effect of empowerment by enabling the employees to gain control in their own work and broader and easier access to information (Mogard 2000). The effects of IT also depend on how the technologies are used by individuals and organisations. The effects can also be negative, such as information overload, a fall in productivity, and feelings of uncertainty and dissatisfaction among its users. (Bouwman *et al.* 2005).

IT has a significant role for many of the other integration elements. For instance, regarding the collaborative foundation, IT use can be beneficial in communicating common supply chain performance measures and generating uniform measurement reports (see e.g. Forslund & Jonsson 2007). Regarding the information attributes, IT provides benefits in information access, flexibility, and quality (see e.g. Mirani & Lederer 1998). Access benefits refer to faster and easier access to internal and external information for decision makers. Flexibility benefits enable manipulating the content and form of retrieved information easily. Quality benefits make the available information more useful, accurate and reliable thus improving its usefulness for strategic planning and operational control. (Mirani & Lederer 1998). Minkus & Nobs (2006) have presented how information system can improve the use and exchange of information in industrial service organisations. IT solution brings increased availability, transparency and quality of information, thus providing a basis for improved collaboration and efficiency in the services provided. Also Simchi-Levi & Zhao (2003) emphasise the role of IT in enabling the availability and visibility of information in supply chain. Ultimately, IS use is assumed to facilitate the designing of new, knowledge-intensive services to customers. (Minkus & Nobs 2006).

Information attributes

Techniques such as information management profiling (Minkus *et al.* 2007b) and critical information instrument (critical matrix) (Soliman & Youssef 2003) can be utilised to identify critical information and to accommodate the form and source/location of information, and the information sharing process. For instance, Minkus *et al.* (2007b) have based their classification of information on the features of information demand, information sources, information gathering, and information provision.

According to Soliman & Youssef (2003) the use of critical information approach can lead to, for instance, the following benefits: reduction in wasted efforts, improved communication, improved supplier selection, reduction in lead-times, increased customer satisfaction, more efficient utilisation of resources, and more effective management of the enterprise (processes). A knowledge management approach utilising critical information will be likely to evoke productivity improvements e.g. related to customer-focus of operations and service quality. Specifically, IT management gains benefits from the identification of critical information. After all, IT is not useful in managing all types of

information. Identifying the critical information also enhances the quality of decision-making process. (Soliman & Youssef 2003). Minkus *et al.* (2007b) have applied the information management profiling in industrial services and claim that it is beneficial as it helps to identify incompatibilities between the information form, location and information sharing process and reduces complexity in information management (and thus also in processes). Matching the information characteristics, source, and practices for sharing it makes information sharing more effective. (Minkus *et al.* 2007b).

Kim *et al.* (2006) show that the exchange of *high quality* information between partners improves the channel coordination and overall responsiveness of the partnership and ultimately market performance. Also higher level of information availability has been connected with success in integrated distribution, as information availability provides better decision-making capabilities at strategic, tactical and operational level (Gustin *et al.* 1995). If information is available, but can not be shared by the supply chain partners, its value degrades exponentially (Kwon & Suh 2004). Thus, in developing the availability of information, attention should be paid to effective mechanisms and systems to share it.

Information sharing practices

Increasing the extent of shared information has been shown to reduce total costs in supply chain, improve order fulfilment rate, and cut order cycle times (Lin *et al.* 2002). Expanding the extent of shared information leads to performance improvements in service context as well. Sengupta *et al.* (2006) have demonstrated that operational performance (speed, delivery, quality) is positively affected by greater information sharing among service supply chain partners. Moreover, information sharing is also positively correlated with financial performance (Sengupta *et al.* 2006). However, with regards to performance, the most essential aspect is how the shared information is utilised (Schroeder & Flynn 2001).

To smoothen the progress of the behavioural change necessary to facilitate integration in the supply chain, empowerment and cross-functional teams are recommended in the literature (e.g. Bowersox *et al.* 1999). In process re-engineering-related literature, also training and education and incentive schemes have been suggested to facilitate the behavioural change (e.g. Gunasekaran & Nath 1997). Empowered employees are able to set their goals and monitor their

own performance and identify and solve problems related to their work (Al-Mashari & Zairi 1999). One factor affecting the extent of *tacit* knowledge sharing between firms is the proximity of facilities that bring about face-to-face relationship facilitating tacit knowledge sharing (e.g. Spring 2003).

Persona *et al.* (2007) have stated that when outsourcing maintenance activities, it is important that the employees of the external service provider are regarded as members of the maintenance team of the buying company. External employees should participate in the social activities, communication and maintenance-related training (e.g. safety issues) just as the internal maintenance personnel. Teamwork is important, as teams are, for instance capable of producing better decisions in problem solving situations compared to individuals (e.g. Persona *et al.* 2007). Teams may enable developing possibilities for sharing of tacit knowledge.

Collaborative foundation

Several researchers have emphasised the importance of supply chain collaboration in achieving the benefits of integration (e.g. Bowersox *et al.* 2000, Barratt & Oliveira 2001). Particularly in service environment, cooperative and committed supplier relationships may help the supply chain members more easily to address the greater ambiguities related to services (Field & Meile 2008). The positive outcomes of collaboration include increased efficiency and effectiveness, improved profitability, and further reinforcement and expansion of the supply chain relationship (Min *et al.* 2005).

Trust has been shown to affect supply chain effectiveness. Investing greater levels of assets in the supply chain relationship (demonstrating commitment) and sharing information increase trust (Kwon & Suh 2004). Trust can facilitate the adoption of electronic payment systems, lead to improved rate of on-time deliveries, reduce cycle times, facilitate cooperation towards continuous improvement and innovation and thus affect financial performance and quality (Corsten & Felde 2005, Handfield & Bechtel 2002, Lin *et al.* 2003, Park & Yoon 2006, Walter *et al.* 2003, Wong *et al.* 2005). Ross *et al.* (2007) suggest that trust is related to the communication media used in a supply chain relationship. In the beginning of a relationship, when the level of trust is low, visually-based communication (e.g. face-to-face discussions, videoconferencing) should be used. When the relationship is a semi-stable relationship with medium level of trust and loyalty, a combination of visually-based and audio-based communication (e.g.

telephone, Skype) is recommended. Adding text-based communication media (e-mail, fax, discussion lists) to the media set is suitable, when high level of trust and loyalty exists and the business relationship is stable. (Ross *et al.* 2007). According to Sahay (2003), further sharing of vital information between supply chain partners leads to building of trust itself, since there is a shared sense of vulnerability of the use/misuse of the information by the other party for opportunistic behaviour.

Integrating the performance management through developing joint performance measures has potential to reduce duplicated activities and leads to more effective and efficient processes, e.g. through eliminating the costs related to low performance (see e.g. Forslund & Jonsson 2007).

The collaborative foundation also affects the other elements of information integration. According to Anthony (2000), collaborative relationships transform how information is shared between companies and thus drive change to the underlying business processes. Li & Lin (2006) highlight in their study the importance of inter-organisational relationship (trust, commitment, and a shared vision) in facilitating information sharing (the extent of information sharing) and information quality. Fynes *et al.* (2004) have shown that the relationship element (supply chain relationship quality operationalised as trust, adaptation, communication and co-operation) has a positive impact on supply chain performance. Supply chain collaboration, i.e. successful partnerships in the supply chain, can lead to improved customer service, better utilisation of resources, a reduction in inventory investment, reduction in emergencies, better working relationships, and increased profit in the supply chain (Willis 1998). One major barrier to increasing the level of supply chain collaboration may be a better understanding of the potential benefits of the relationship and the distribution of these benefits among supply chain members. After all, improving integration may allocate costs and value-added activities among supply chain participants in an unexpected and undesirable way. (Sahin & Robinson 2005).

Time-related issues

To improve the performance related to timing in supply chain, two inter-related approaches have been suggested in the literature: information technology and process development (e.g. Hewitt 1999, Kwan 1999). Jayaram *et al.* (2000) have also gained evidence in their study that combining the utilisation of the

information system infrastructure and process development improves the time-based performance of a supply chain.

In general, standardisation, i.e. use of standard methods, materials, parts, and processes, simplifies operations and brings time savings. Standardisation may create focused competence for instance in relation to processes and thus reduce causes for delays, eliminate unnecessary phases in the process, and create possibilities for performing some phases concurrently (Jayaram *et al.* 2000). Applying standard procedures in information sharing might be one solution to cut the lead-time of information sharing and improve the timing of information sharing.

Four common strategies to reduce the total cycle time (lead time) are suggested by Towill (1996): *Elimination*, i.e. removing a process or an activity, *compression*, i.e. removing time within a process or activity, *integration*, i.e. re-engineering interfaces between successive processes, and *concurrency*, i.e. operating processes or activities parallel. Lead-time particularly affects the dynamic response in a supply chain (see e.g. Mason-Jones & Towill 1999). Quite similarly, Jayaram *et al.* (2000) describe their approach to cycle time reduction (based on e.g. Millson *et al.* (1992)) involving standardisation, reducing slack time and bottlenecks, eliminating steps, and speeding up processes through the use of computers, and parallel processing.

Time compression generally allows supply chain companies more easily to detect and understand the cumulative effect of problems in the chain and quickly respond to them. Reduced cycle time also speeds up the cash-to-cash cycle and thus enhances the cash flow and financial performance of chain members. (Brewer & Speh 2000).

2.7.4 Summary on development means and performance effects

Based on the literature review, means to develop integration along the six information integration elements and their potential performance effects in supply chain are summarised in Table 2. Implementing the means is more likely to affect several elements of integration instead of just one, as the elements are inter-related.

Table 2. Ways to develop information integration and their effect on performance in supply chain.

Element	Development means	Potential performance effects
Processes and activities	Modelling the processes and activities (e.g. Ishikawa diagrams, process flow charts) Development of processes through elimination, compression, integration, and concurrency Deploying IT and standardisation Measuring the process performance and continuous development Co-location of employees between supply chain companies	Reduced complexity in processes. less delays Cost and time savings Better identification of value-adding and non-value-adding activities Better opportunities for waste reduction More effective management of processes Better responsiveness to changes Encouraging continuous improvement and innovation Improved communication Faster cash-to-cash cycle and improved financial performance
Information technology use	Shared / harmonised/ integrated / interoperable information systems between supply chain partners Increasing the proportion of electronically shared information	Less rework and delays Cost and time savings Reduced complexity in processes, elimination of unnecessary activities Additional revenues Empowerment of employees Improved information availability and quality (timeliness, relevancy, flexibility) Increased extent of shared information Increased transparency/visibility in supply chain Improved customer service and responsiveness Faster decision-making Improved collaboration (planning, joint performance measurement) Possibilities for process improvement and organisational changes Better asset utilisation Faster time-to-market, penetrating new markets Higher return on assets, higher shareholder value Facilitated design of new services

Element	Development means	Potential performance effects
Information attributes	Matching the characteristics of information and process of sharing it (e.g. information management profiling, critical information matrix) Increasing the proportion of electronically shared information	Improved communication Reduction in lead-times Improved customer satisfaction More efficient resource utilisation More effective management of processes Improved service quality Improved quality in decision-making (operational, tactical, strategic) Reduced complexity in information management and processes Enhanced IT management More effective information sharing improved channel coordination Improved responsiveness Improved market performance
Information sharing practices	Developing formal and informal interaction routines Proximity in facilitating tacit knowledge sharing Empowerment, use of cross-organisational teams Incentive schemes Training and education Joint workshops Co-location, rotation of individuals between organisations Ensuring the social interaction between companies	Reduced costs Shorter order cycle times Improved operational performance (speed, delivery, quality) Improved financial performance Increased possibilities for sharing tacit knowledge Improved communication. more efficient problem solving Enhanced coordination Performance improvements, as firms understand how each other works
Collaborative foundation	Longer-term orientation Use of cross-organisational teams Commitment through use of reward and compensation systems / sanctions Co-location or rotation of individuals between organisations Training, workshops, etc. Investments in relation-specific assets (e.g. IT) Developing joint performance measurement	Increased extent of information shared Improved information quality Facilitating process changes Improved process efficiency and effectiveness Improved customer service Improved resource utilisation Increased profit, improved profitability Reduced complexity, less duplicated activities More efficient problem solving Improved financial and quality performance Encouraging continuous improvement and innovation Reinforcement and expansion of the supply chain relationship

Element	Development means	Potential performance effects
Time-related issues	Development of processes through elimination, compression, integration, and concurrency Standardisation of methods, systems, and processes Deploying IT	Reduced complexity in processes Cost and time savings Improved responsiveness improved planning and decision-making Faster cash-to-cash cycle and improved financial performance

2.8 Framework for analysing and developing information integration

This study aimed at developing a comprehensive framework for examining and developing information integration in service supply chain. The framework for information integration should act as a tool for both analysing the present state of integration and identifying the goals and means for developing integration. Besides providing a comprehensive set of elements to examine information integration, the framework should take notice of the context of integration and the relationship between integration and supply chain performance.

Six elements of information integration *(RQ1A)* were identified: processes and activities, information technology use, information attributes, information sharing practices, collaborative foundation, and time-related issues. Compilation of the elements and their contents is presented in Table 3. The holistic view of this study differs from some other perspectives presented concerning supply chain information exchange. For instance, Moberg *et al.* (2002b) suggest isolating the information exchange from other factors of integration, such as collaboration, to give managers strategy recommendations to improve information sharing among supply chain partners. The framework of this study rather suggests that information sharing *can not and should not* be fully separated from the other inter-related elements of integration, as improvements in information sharing can be derived from the other elements.

Table 3. Summary of information integration elements.

Element	Definition	Contents/operationalisation
Processes and activities	The extent of process integration and the scope of information sharing in the processes.	Process coverage of information sharing Degree of process integration
Information technology use	The extent of information technology use and technology integration in the supply chain information sharing.	Information systems coverage Information systems integration
Information attributes	The characteristics of information to be shared in a supply chain.	Information form Information quality Information availability
Information sharing practices	The extent (volume) of information sharing and frequency of activities undertaken to advance information sharing in a supply chain.	The coverage (extent) of information sharing practices The frequency of communication/interaction
Collaborative foundation	Status of the relationship issues and practices underpinning the collaboration and thus integration in a supply chain.	Shared goals Shared resources Trust Commitment Performance measurement
Time-related issues	The speed and timeliness in information sharing.	Timing of information sharing Information lead-time

The extent of integration *(RQ2A)* in the framework is described and defined through the levels of integration. Three levels are identified: 1) transparency, 2) commitment/coordination, and 3) integrative planning. When moving from level 1 to level 3, the integration develops from low to high, the emphasis of integration expands from operational to strategic, and the degree of collaboration increases from mere interaction to greater interdependency. The framework differs from some earlier frameworks developed to analyse integration in supply chains. For instance, in Spens' (2001) framework for process integration the different components (elements) of integration as such reflect the different levels of integration. In the framework of this study, the six different elements of information integration are assumed to exist on each level of integration and the levels are then defined based on how advanced or well developed the different elements are.

The framework suggests a differentiated approach to information integration in supply chain as it includes the effect of context on integration. Six contextual factors (RQ2A) influencing the level of integration in service supply chain were

identified: level of interdependence, degree of complexity of the services (i.e. uncertainty in service mix/specification), closeness of the customer-service provider relationship, type of supply chain resources, uncertainty in service volume, and order winning criteria. Propositions on the effects of the contextual factors to the level of integration were made. Service supply chain dyads with shared resources, routine type of services, loose customer-service provider relationship, cost as the order winner, low level of interdependence and low service volume uncertainty are proposed to have a low level of integration (level 1). On the contrary, service supply chain dyads with high buyer focus, customised services, close customer-service provider relationship, flexibility and/or quality as the order winner(s), high level of interdependence and high uncertainty in service volume are assumed to have a high level of integration (level 3). In between settles then the level 2 integration. This kind of framework for the contextual factors also offers the possibility to view service providers with similar contextual background as a group to simplify the analysis on the level of integration.

The relationship between the level of integration and elements of integration can be seen as bidirectional: contextual factors provide restrictions and possibilities regarding the level of integration and thus determine how far the elements can and should be developed in a supply chain dyad, i.e. the status of the elements. On the other hand, developing the various integration elements is the key to enhancing the level of integration in a supply chain dyad.

The ultimate goal of information integration is improved supply chain performance. Based on the literature review it is suggested that the supply chain performance should be viewed based on the specific performance goals of each supply chain dyad and the performance measurement tailored to the supply chain needs (RQ3A). However, performance management should cover the four fundamental aspects of supply chain performance (cost, time, quality, and flexibility). Moreover, three levels of performance measures and thus performance management can be identified: operational, tactical, and strategic. As the integration level in supply chain moves from lower to higher integration, the importance of long-term benefits and thus strategic measures grows. In a dyad having a low level of integration, the emphasis is more on operational performance measures. The more detailed performance goals and measures are defined based on the supply chain explored, and based on the goals the appropriate ways to develop integration are selected. As trade-offs exist when choosing the balance between the various aspects of supply chain performance, this kind of differentiated approach allows putting the emphasis on the

performance issues that are particularly relevant to the specific supply chain dyad to be analysed. Moreover, given the fact that integration activities consume resources, it is important to be aware of the performance impacts of each element of information integration, which helps in prioritising the resources for integration optimally in the supply chain, i.e. choosing 'a specific set of integration practices to gain performance synergies' as proposed by Das *et al.* (2006).

The theoretical framework for information integration combining the context, extent, and elements of integration, and the performance effects, is presented in Figure 5.

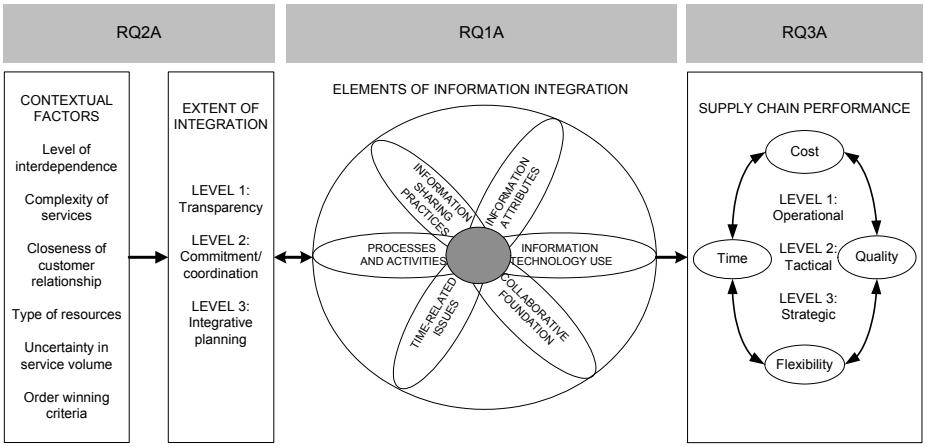

Fig. 5. Theoretical framework for information integration in service supply chain.

To conclude, examining external information integration in a supply chain requires a dyadic perspective in which the exchange between the two supply chain parties is highlighted. Considering the mere information flow is not enough, but rather all four layers of integration (processes, flows, systems and technologies, and actors) should be covered in the framework to ensure the comprehensiveness of the approach. After all, managing information necessitates also managing technology to ensure the effectiveness of the information systems. Moreover, information flows through the supply chain processes and acts as the link between the processes. Finally, actors in the supply chain have a significant role in ensuring the effectiveness of the information flow.

When considering the elements of information integration in this study against the classification into attitudes, patterns, and practices in supply chain integration (e.g. van der Vaart *et al.* 2006, van der Vaart & van Donk 2008), it can

be noted that dimensions from all three categories are present. Processes and activities represent the patterns related to the areas (scope), where integration is done. However, the element also reflects the degree of 'joint improvement' and 'information planning' used by van der Vaart *et al.* (2006) as integration practices. Information technology use illustrates the technologies used in achieving integration and thus integration practices. Information sharing practices is an element to describe the practices of integration through the extent of information sharing practices (related to the element 'planning information' used by van der Vaart *et al.* (2006)) and the pattern of communication through the frequency of interaction. Collaborative foundation covers mostly the attitudes in supply chain dyads, which have in earlier research been described e.g. by van der Vaart *et al.* (2006) through 'long-term relationship' and 'collaborative behaviour'. However, collaborative foundation has also some dimensions describing the practices; sharing resources among supply chain partners and joint performance measurement. Information attributes and time-related issues are elements that are more difficult to place in the categories of attitudes, patterns and practices. However, they are clearly related to the communication patterns in the supply chain in terms of how and when the information is shared. Moreover, the information attributes and the time element represent the orientation or objectives in information sharing which are often related to the quality, availability, and speediness. Perhaps an additional common denominator, '*structures*', should be taken into use to better be able to describe the processes and activities, information attributes, and time-related issues. The 'structures' can be affected by the integration patterns, practices, and attitudes.

Adjusted context-practices-performance framework

The starting point of this study was the context-practices-performance framework presented by Ho *et al.* (2002) and Ho & Duffy (2000) and later modified by van Donk & van der Vaart (2005b) for supply chain integration. In the course of the study, however, it was realised that there are not only practices affecting the supply chain integration and hence the supply chain performance. Rather, a set of practices, patterns, attitudes (van der Vaart *et al.* 2006, van der Vaart & van Donk 2008) and 'structures' can be identified. These are affected by the contextual setting of integration and define thus the level of integration in a supply chain together with the context. Finally, the level of integration affects the performance in the supply chain. On the basis of these observations concerning the framework

for service supply chain presented in Figure 5, a more general framework for supply chain integration, adjusted from the original context-practices-performance framework (Figure 3), can be established. The framework is presented in Figure 6.

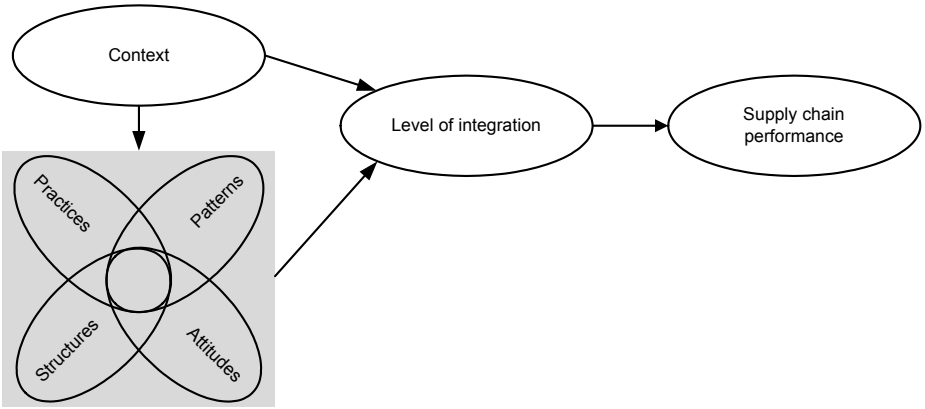

Fig. 6. Adjusted context-practices-performance framework for supply chain integration.

The framework in Figure 6 emphasises that supply chain integration, regardless of the supply chain environment or the focus of integration chosen (information, organisational, or process), should be handled as a composite of practices, patterns, attitudes, and structures in order to view it comprehensively enough.

3 Conducting the study

The empirical part of this study was carried out in a steel industry maintenance service supply chain. A supply chain with a large global steel manufacturer and group of service providers offering maintenance-related services to it was chosen to be examined. Steel industry was chosen as the empirical research environment of the study as the research project was a follow-on for previous projects carried out in steel industry supply chain and thus some knowledge and contacts in the industry already existed. This study was conducted as a part of the SEBI (Semantic Business Interoperability) project which continues the SteelNet research performed during the years 2002–2006 in a steel industry supply chain in Finland. All research partners of the project had already been co-operating with the local steel industry in earlier projects. SEBI project was carried out during the years 2006–2008. The companies were already committed to SEBI project and had a positive attitude towards the research work. Through the persons already involved in earlier projects it was easy to get contact to the key persons to be involved and used as informants in the study.

Maintenance services were chosen as the focus due to the lack of research among the supply chain links between manufacturers and service providers and scarce empirical knowledge on service supply chains and their practices in information sharing. Moreover, integration in support processes, such as the maintenance process, has been very little examined so far, and was thus considered an interesting research focus. The service focus adds on the knowledge gained in earlier SteelNet research which had its main focus on supplier-buyer collaboration and information technologies in manufacturing context. Moreover, the information sharing in maintenance processes was expected to experience some changes in the near future through the introduction of a new maintenance information system at the focal company's local facilities. Thus, the commitment to pay attention to the maintenance information sharing and developing it was high in the case supply chain companies of this study and a clear practical need for development existed.

Information sharing related to annual overhaul shutdown was chosen as the focus area of data collection as it involves both planned and unplanned maintenance and a large group of external service providers and thus represents the complete maintenance field at the focal company very well. Three production lines were included into the data collection to limit the case to a more manageable entity. The production lines were chosen so that the scope of the maintenance

activities shifts from the larger scope in hot rolling mill, through hot strip mill with a medium scope, to a narrower scope in hot rolled plate and strip products.

The criteria for selecting the mechanical maintenance service provider companies to be included in the study was, that the service provider companies would be involved in the annual overhaul on two, or even all three, of the production lines under examination. Inclusion of the engineering offices (providing maintenance-related planning services) in the study was discussed in a workshop with the company representatives and considered necessary, as their services play an important role in the process of annual overhaul. They are also linked to the mechanical maintenance service providers' work. For instance, delays in planning services may at worst cause a delay in the mechanical maintenance work during the annual overhaul, or shift some tasks to be performed only during the next shutdown.

The links between the theoretical part of the study and its operationalisation in the empirical context are described in Figure 7. Through the process of theory matching between the theoretical framework for information integration and empirical observations in the case supply chain (presented on the timeline) answers to research questions 1B, 2B, and 3B in this study are generated.

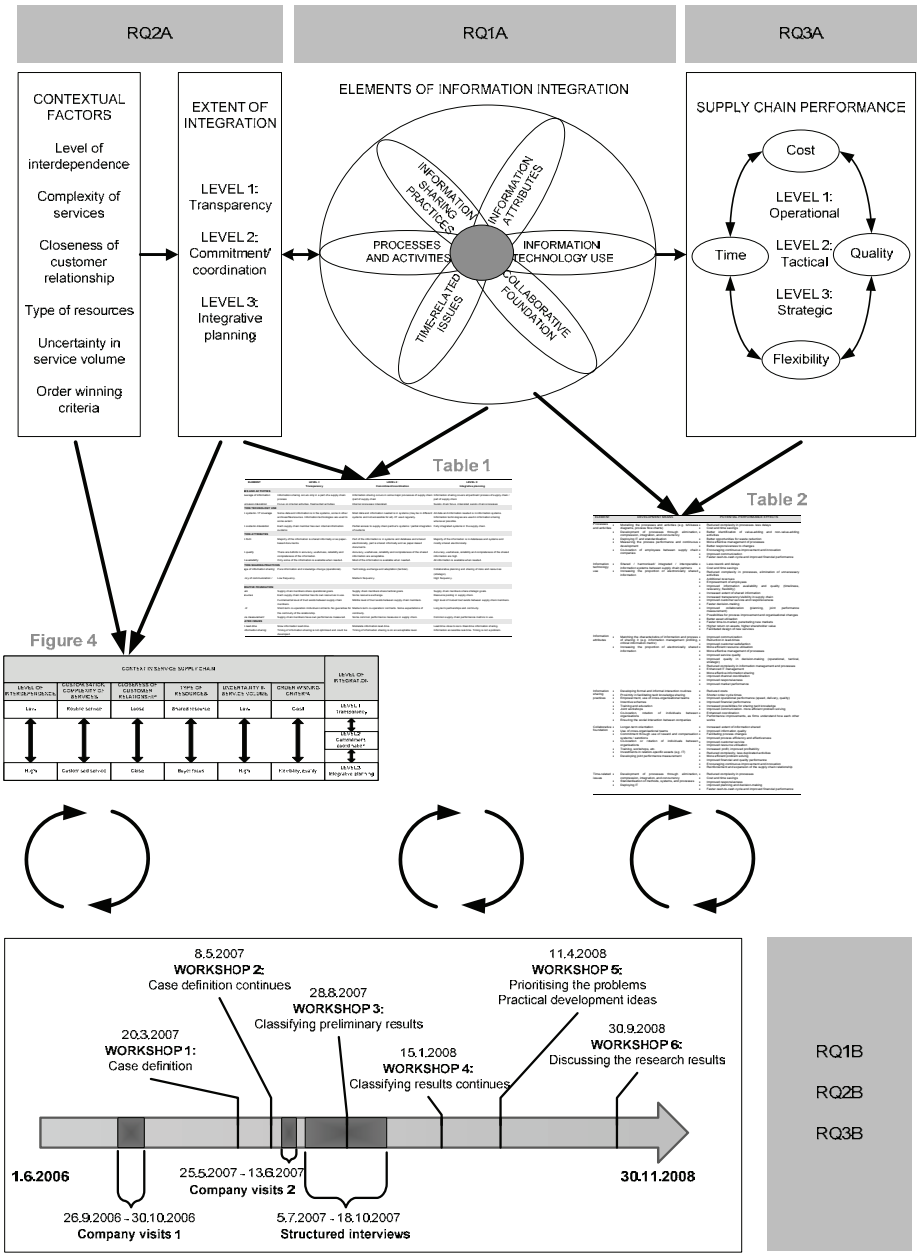

Fig. 7. Linking the theoretical and empirical research streams in the study.

3.1 Collecting the data

The empirical data was collected during years 2006–2008. The main data collection methods were structured interviews and workshops organised for the case supply chain key informants. Additionally, participative company visits and company documents received during the visits and interviews were used to underpin the data collection. Phases of data collection and their timing are presented in Figure 8 and described later in detail.

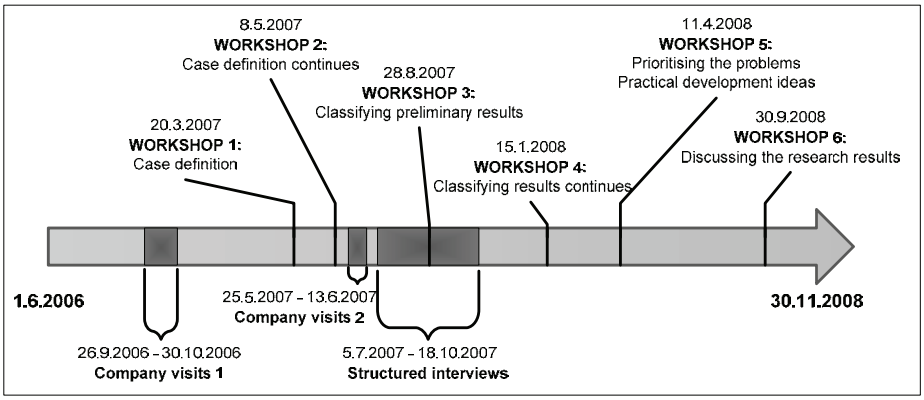

Fig. 8. Phases of data collection during the SEBI project 2006–2008.

The companies involved in the study, their role in the maintenance service supply chain, and their participation in different data collection phases are indicated in Table 4.

Table 4. Participation of the maintenance supply chain companies in data collection.

Company role in the case supply chain	Number of companies included in the study	Number of persons involved from the companies altogether	Particip. company visits	Particip. workshops	Particip. interviews
Focal company	1	9	X	X	X
Information system service providers	2	10	X	X	
Mechanical maintenance service providers	4	4		X	X
Engineering offices (maintenance-related planning service providers)	2	3		X	X
In total	9	26			

In the following, the motives, methods, and results of different data collection phases are described in more detail.

Company visits

The data collection was first started by conducting company visits in the focal firm and in two significant information system provider companies that work in close co-operation with the focal company being responsible for the engineering and maintenance of some maintenance-related information systems. Two separate rounds of company visits were performed during the study. The agenda and list of questions/discussion topics for the visit were sent to the companies in advance. The visits lasted 2–3 hours. They were taped and several researchers in the research group took notes on them. Afterwards a summary report on the company visits was written by the researchers and sent to the participants for commentary.

The aim of the first round of company visits was to create pre-understanding on the definitions, meaning, and implementation of information integration in the case supply chain. During the first visits the research project and project group was introduced to companies. Companies also gave a short presentation on their operations and agreed on contact person(s) in the company for the project. The discussion topics were at this point on a very general level and covered the present state and future goals of information integration in the companies. The areas included were

- the meaning of information integration for the company,
- present and future barriers/problem areas related to information integration,
- present and future benefits of information integration,
- present and future information systems in use, and
- information integration needs in the company.

During the first company visits researchers also collected general company material, such as annual reports and brochures of the companies.

During the second round of company visits the empirical case had been already roughly sketched and the aim was to gather more detailed information regarding the operations under examination in the practical case, i.e. information integration in maintenance process. The main topics discussed during the company visits covered

- the processes in maintenance, critical information in them, main information systems in use and potentially missing information,
- the operation model between different actors in the case supply chain; how and what information is shared, problem areas in collaboration, sharing of tacit knowledge, and
- maintenance information systems in the focal company and the new maintenance information system that will be introduced in the focal company.

During the second round of visits researchers also got access to some company documents such as presentations about the maintenance operations and maintenance organisation in the focal company. In general, the company visits were helpful in achieving a common understanding on the definition of information integration and in increasing the commitment of companies to the research.

Structured interviews

The principal data collection method in this study was the entity of structured interviews conducted in the case supply chain companies during summer and autumn 2007. The aim of the interviews was to gain more detailed information on the current level and context of information integration in the case supply chain dyads between the focal company and the service providers. Another objective was to acquire information on the performance measurement and performance goals in the dyads. Based on the literature review, preliminary theoretical

framework, and knowledge gained on case companies during the company visits and first two workshops, a structured interview protocol was developed. The structured interview method was chosen to ensure the comparability of the approach and results between the interviews.

The first part of the interview frame consisted of questions pertaining to company background (or respectively background information on the maintenance and its organisation in the focal company) and the relationship/co-operation between the service providers and the focal company. The core of the interview frame included the interview questions dealing with information sharing (between the service providers and the focal firm), which were divided into three parts: information sharing before, during, and after the annual overhaul. This division was made to ensure that the interviewees would not only concentrate to a certain part of the maintenance process, but instead the whole entity of information sharing related to the annual overhaul would be covered in the interviews. This classification also demonstrates the distribution of maintenance process into 1) planning, 2) implementation (execution) and 3) control (functional testing and feedback) (see e.g. Söderholm *et al.* 2007). From the service providers' perspective a similar division can be made to information sharing related to 1) offering, 2) delivering, and 3) evaluation of the services (see e.g. McFarlane *et al.* 2008). The interview questions focused on obtaining detailed insights into

- the activities and roles/responsibilities of supply chain actors in the maintenance processes,
- what information is shared in supply chain, with whom, how and when,
- procedures for information sharing and their consistency,
- how and which information technology/tools/systems are utilised in supply chain information sharing,
- hinders or problem areas related to information sharing (also related to quality, availability, and form of information),
- whether some critical information is missing,
- the factors facilitating information sharing,
- how the shared/collected information is utilised,
- how performance is measured in maintenance process/maintenance service supply chain, and
- preliminary performance effects that could be gained by developing the supply chain information sharing.

The contents of the interview frames for the focal company and the service providers were essentially congruent. However, in the interviews conducted in the focal company, the question concerning the potential performance effects of developing information sharing in the supply chain was included in the questions dealing with development possibilities of the information sharing during the interview, whereas for service providers it was added on the question list separately. Another point worth noting is that in the interviews with engineering offices more emphasis was laid on the information sharing before the annual overhaul, i.e. the planning stage, and less on the implementation (during the annual overhaul) as majority of the information sharing between engineering offices and the focal firm occurs before the annual overhaul begins. The interview questions used in the focal company are presented in Appendix 1. The interview questions for service providers can be found in Appendix 2.

The interviewees in the focal firm (3 interviewees) were persons responsible for the planning and supervising of maintenance work of the selected three production lines. The interviewees in the mechanical maintenance service provider companies (4) were supervisors or other persons responsible for certain maintenance contracts performed at the focal firm's facilities. The interviewees in the service provider companies were selected based on a contact information list of maintenance supervisors during the annual overhaul that was obtained from the focal firm representatives. The names of two important engineering offices and their contact persons had come up in the interviews at the focal company. The persons interviewed in the engineering offices providing maintenance-related planning (2) were superiors of the mechanical designers. Inclusion of the engineering offices in the study was also discussed in a workshop with company representatives and considered necessary. When choosing the interviewees from service provider companies it was also carefully ensured that they were the persons that had been co-operating with the focal company and had thus the necessary knowledge concerning the information sharing between their own company and the focal company.

The interviewees were informed of the purpose of the study and interview themes in advance by phone and a confirmation e-mail was sent after the phone call. The duration of the structured interviews varied between 1.5 and 2.5 hours. All interviews were taped and documented during the interview and later written up (selective transcription). A summary research report was written based on the interviews and delivered to the interviewees and the steering group of the project for verification. During the interviews, supporting company documents, such as

minutes of planning meetings, schedules of the annual overhaul, presentations, organisation charts, etc. were collected and used as supporting research material whenever justified. Presentation material of the closing session of the annual overhaul was distributed to the researcher afterwards, as it only took place after the interviews had already been conducted.

Based on the interviews a detailed description of the activities and information flows in the case supply chain dyads was formed. Information on the services provided and the relationship between FC and service providers was gained for the analysis of the contextual setting. Factors facilitating and hindering information integration were identified and development areas in case supply chain information sharing were listed. Interviewees' perceptions on the performance effects of information integration contributed to analysing the link between integration elements and performance. Thus, the interviews contributed to justifying the importance of integration elements, analysing the current level of integration and the contextual setting, and framing the development scheme for the case supply chain.

Workshops

Altogether 6 workshops were organised for the company representatives during the research project. Workshop program and material (such as topics of group discussions) were sent to the participants in advance. Workshop participants included company representatives from the maintenance supply chain (including also the information system service providers) and researchers of the project group. Presentations and group discussions in the workshops were taped and documented. A written summary report of the workshop was sent to all participants after each workshop for verification.

Workshops 1 and 2 dealt with defining the empirical research case and a preliminary determination of the actors, processes and information to be included in the empirical research. They also provided important information regarding the contextual factors present in case supply chain. In workshop 1 the topics under discussion included:

- Key activities/processes, roles and objectives in maintenance,
- key information in maintenance process,
- key actors in the maintenance supply chain regarding the information flow, and

- the procedures and systems used for information sharing (current and future).

Finally, based on the discussion, some preliminary ideas on development areas in maintenance service supply chain information sharing were debated in the workshop.

In workshop 2, a classification of service providers related to maintenance process was done based on complexity of the services (degree of customisation) and closeness of the customer relationship. The framework for classification was adapted from the literature (see e.g. Bask 2001, Mäkelin & Vepsäläinen 1990). Workshop 2 pierced deeper in the maintenance service supply chain information sharing by covering themes, such as

- identifying critical information,
- transferring tacit knowledge,
- understanding shared objectives/goals,
- methods used in information sharing between the companies, and
- the problem of defining common concepts between supply chain actors.

In workshop 3 the preliminary results of the structured interviews were discussed and categorised. The first group discussion involved classifying the maintenance-related information shared in the supply chain into different forms of information. The classification of Minkus & Nobs (2006) was used: Data and information in databases, documents provided electronically, paper-based documents, and informally shared information. Categorising the shared information in the case supply chain provided the basis for later recognising the overlappings, inconsistencies, and development possibilities in the information form and the practices for sharing it. In the second phase, the preliminary development areas in information integration in the case supply chain were grouped under the six elements of information integration (processes and activities, information attributes, information technology use, information sharing practices, collaborative foundation, and time-related issues). Organising the development areas in information sharing under the elements of integration demonstrated the importance of the elements in the case supply chain and helped in determining the elements with most urgent development needs. Thirdly, workshop 3 also gave support to some final decisions in defining the case supply chain, such as concentrating on the information sharing related to the annual overhaul.

Workshop 4 was arranged to gather information on case supply chain performance goals and to validate the importance of all six information

integration elements in developing the supply chain performance. First part included a group discussion where the supply chain performance development targets in the case supply chain were roughly rated by using three categories: low, medium, and high importance. The second task was to assess the importance of the six different information integration elements and their subcategories for the performance development in the case supply chain. The results complemented the data concerning performance goals of integration gathered in the structured interviews. Rating the importance of the different integration elements in developing the case supply chain performance provided guidance for evaluating the importance of the elements in the case supply chain.

Workshop 5 was organised to identify the most important problem areas of information sharing in the case supply chain and to discover practical development activities to eliminate the problems. The problem areas, which were earlier identified in the structured interviews, were used as a basis. The main causes of the problems were identified based on Ishikawa diagram (five groups of causes; information users, information systems, information sharing procedures, maintenance process, and other reasons). The problem areas were prioritised by giving them 'problem priority numbers', i.e. assessing the probability of occurrence of the problem, the importance of the problem, and probability of detecting the problem. This technique was analogous to the risk priority number technique used in FMEA (Failure Mode and Effect Analysis). Ishikawa diagrams were also employed when conceiving practical development guidelines for eliminating the identified problem areas in case supply chain information sharing. Finally, the development ideas were prioritised and a consensus on three main action points for developing case supply chain information sharing was formed. The prioritisation was carried out in three phases. First each workshop participant selected, in his own opinion, five most essential development means. In the second phase the participants formed two groups, and each group agreed on three most important development activities. Finally, through a guided discussion among all workshop participants, the selected development means were prioritised and combined to be captured in three main action points.

Workshop 6 was organised in order to present the final research results (i.e. the analysis on the level of integration and the development guidelines) to the company representatives and to enable a discussion on the results among the researcher and company representatives. The pre-determined discussion points included the current and target level of integration in case supply chain dyads, practical means to facilitate integration, and their potential performance effects.

No theoretical frameworks or particular tools were used to guide the discussion. The role of this last workshop was merely to obtain final validation for the empirical research findings.

Company documents

A set of company documents including e.g. maintenance schedules, checklists, memos, and presentations was obtained along the other data collection phases. The company documents acquired during the company visits and interviews played an important role in defining the actors and roles in the maintenance process, and in assuming a general view on the procedures for information sharing and the maintenance processes. They also provided practical examples of the documents shared between the supply chain partners, demonstrating thus e.g. the presentation form and quality of information shared.

A list of company documents that were received during the interviews and company visits is provided in Table 5. For presentations, the name of the compiler or presenter has been left out to preserve the anonymity, and instead, just the role of the presenter's company is notified.

Table 5. Company documents used in this study.

No	Company document
1	Presentation: 'Importance of information integration in maintenance at the focal company'
2	Organisation chart presenting the maintenance organisation at the focal company
3	List of external service providers and their persons responsible in the annual overhaul 2007
4	Memo of a planning meeting of the annual overhaul of the hot strip mill in 2007
5	Memo of a daily meeting during the annual overhaul concerning the schedules (for the focal company's own employees only)
6	Overview on the tasks of planning the annual overhaul and their timing at strip mill in 2007
7	Overview on maintenance tasks/work orders during the annual overhaul 2007 regarding hot rolled plate and strip products (printed out from the maintenance information system at FC)
8	List of inspectors and supervisors during the annual overhaul regarding hot rolled plate and strip products
9	List of schedules for the annual overhaul at various production lines regarding hot rolled plate and strip products
10	A graphical presentation of the schedules for annual overhaul at various production lines regarding hot rolled plate and strip products
11	List of mechanical maintenance tasks regarding the hot rolled plate and strip products line during summer 2007
12	Check list of operational maintenance tasks and work supervision at pickling line
13	Schedule and contact information of lorries for washing, acid, and suction at pickling line in July 2007
14	Check list for the performed maintenance tasks and feedback for the closing session of the annual overhaul 2007
15–16	Material from the closing session of annual overhaul:
	Summary on the reparations during the annual overhaul 2007 at the strip mill
	Industrial safety report concerning the annual overhaul 2007 at the strip mill

3.2 Analysing the data

The qualitative research data was analysed in each phase of the research process throughout the study (see e.g. Strauss & Corbin 1990). Moreover, the case analysis was an iterative process, as distinctive for abductive research, and moved backward and forward between the research activities and data collection and theory. This kind of reliance on theoretical propositions in parallel with reviewing and evaluating them in accordance with the case description is identified as one option to conduct the analysis of case study material by Yin (2003). The analytic technique in this study can be categorised under the special type of pattern matching, explanation building (see e.g. Yin 2003), as it attempts to demonstrate the causal links between the elements and level of integration, between the level

of integration and contextual setting, and between elements of integration and supply chain performance.

Several analytic manipulations were used to put the case evidence in preliminary order (see Miles & Huberman 1994): putting information into different arrays, creating data displays, and organising information based on a temporal scheme. The context-practices-performance scheme formed a starting point, around which the data analysis was built. The elements of integration (presenting the practices) were chosen as the core category, to which the other theoretical entities (contextual factors and supply chain performance) were linked.

Another choice made during the data collection and analysis was the dyadic view, thus focusing on the reciprocal relationships in integration both from the focal company and service provider perspectives. Although the research was conducted in a single supply chain, there are six supply chain dyads between the focal company and service providers to be viewed in this study. The unit of analysis was chosen to be a dyad, as it better enabled identifying the possible differences within the chain specifically between the two differing types of service providers. The differing characteristics of the service providers involved in the case supply chain led to a grouping involving two types of focal company-service provider dyads: engineering office-focal company and mechanical maintenance service provider-focal company dyads. The idea of two groups of dyads shaped up during the structured interviews as it was realised that the contextual setting among the two engineering offices and then again among the four mechanical maintenance service providers was consistent.

The information sharing was already before the interviews divided into three distinct stages: maintenance planning (for service providers: service offering and planning), maintenance execution (service delivery), and control and feedback (service control and evaluation). This was done to ensure obtaining a holistic view on information sharing along the entire service process and its interfaces with the maintenance process in focal company and to outline the shared information according to sequence in time.

During the research, the research material such as company visit reports, workshop reports, interview transcriptions, summary report on interviews, and the received company documents were read and glanced through several times. Various categorisations (e.g. the elements, context, and performance) were used, and themes and issues related to the categories were underlined from the text and listed later in other documents or researcher's own notes. Similarities between the themes or categories were looked for to enable simplifying and describing the

research data. This was done either by the researcher, or in the workshops, where part of the data analysis occurred, as the categorisations were deployed in them and initial research results discussed and prioritised. If the analysis was conducted in the workshop, the researcher, however, took the liberty to complement and adjust it later in the research process.

The data analysis can be divided into four entities. *Case supply chain description* was important to be formed to become familiar with the case and thus also the context of integration and it formed the basis for other data analysis phases. *Analysis on the elements of integration* seeks answers to RQ1B. *Analysis on the extent and contextual setting of integration* aims at answering RQ2B. *Analysis on the performance effects and development of integration* reflects the data analysis process in answering RQ3B. These entities, however, are inter-related and the back and forth movement between the entities constantly occurred during the research. Figure 9 illustrates the analysis of the data through categorisations used during the research process of this study. Throughout the study, theory was used to support the empirical interpretations, and many of the categorisations originally emerged from the theoretical study.

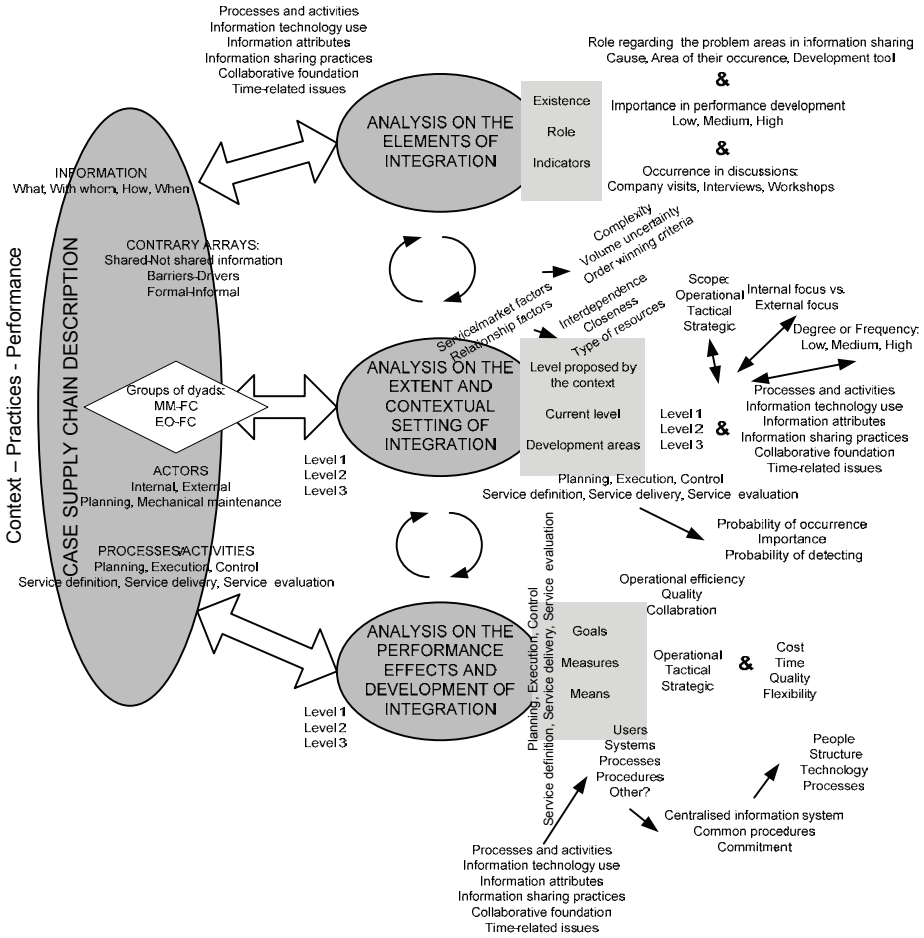

Fig. 9. Analysing the data during the research process.

4 Analysis of information integration in steel industry maintenance service supply chain

4.1 Maintenance process and maintenance management

Silver (2004) has justified the need for process level studies in supply chain management as he considers supply chains as integration of processes across boundaries of organisations and claims that many different supply chains within a firm exist, managed at the process level. This study has maintenance process as its practical research environment. More specifically, the maintenance processes related to annual overhaul shutdown are explored. According to Piispa (2007), there is to date only very little research viewing shutdowns from the organisational or process perspective.

Maintenance can be defined as an activity that aims to optimise the availability and reliability of production equipment and maintain its operability at acceptable cost level (Coetzee 1997). Maintenance is viewed as a support function for manufacturing companies. However, its strategic importance for manufacturing companies with significant investments in physical assets is considerable, and it can truly affect the competitiveness of companies. The way maintenance is performed affects the availability of production facilities, the volume, quality, and cost of production, and safety of the operation. (Visser 1998, Tsang 2002). Maintenance costs are a major item of expenditure for manufacturing industry. In Finland, for instance, the average maintenance costs are about 5.5% of company turnover, but they can rise even to 25% of company turnover (Komonen 2002).

There have been attempts to take a more holistic approach to maintenance (e.g. Söderholm *et al.* 2007, Coetzee 1999) and to emphasise the strategic importance of maintenance (e.g. Tsang 2002). However, the maintenance supply chain, that is the inter-relations with external service providers, has not been particularly covered in research. Maintenance and repair services can be classified as equipment support services focusing on property, and have high importance to the customer company's core business activity. Thus, it is important that the service provider has experience on purchaser's industry and good reputation. The service provider should ideally also be located nearby to provide emergency service. (Fitzsimmons *et al.* 1998).

The approach to maintenance has evolved from reactive maintenance to a more integrated and proactive approach (e.g. Garg & Deshmukh 2006). This highlights the importance of maintenance planning and thus the meaning of information sharing. Information is one of the maintenance inputs (Visser 1998) and information flow should be carefully considered in maintenance management. Indeed, sound maintenance management requires a lot of interaction with other business functions (e.g. Garg & Deshmukh 2006) and supply chain partners, such as maintenance service providers and suppliers of materials, spare parts, and tools. Moreover, nowadays maintenance functions or part of them are often outsourced to an external service provider as companies pursue cost reductions and concentrate on their core competences. Thus, external services should be considered as an input to maintenance system or process as well (e.g. Visser 1998). Outsourcing often leads to a more complicated maintenance supply chain to be coordinated. This will further highlight the importance of swift information flow in maintenance supply chain and bring out the need for integrated information systems between the various partners of maintenance supply chain. The impact of IT on maintenance management is still a relatively new research area, but the opportunities of IT have been recognised for instance by Pintelon *et al.* (1999). Considerations on maintenance information systems in the literature have mainly focused on improving the internal process of maintenance and internal integration. Too little attention to deploying the information systems in integrating the external parties to the maintenance process has been paid. However, the focus in maintenance management is now moving towards internal and external relationships and thus also external integration. Figure 10 describes the evolution of maintenance management during the past decades.

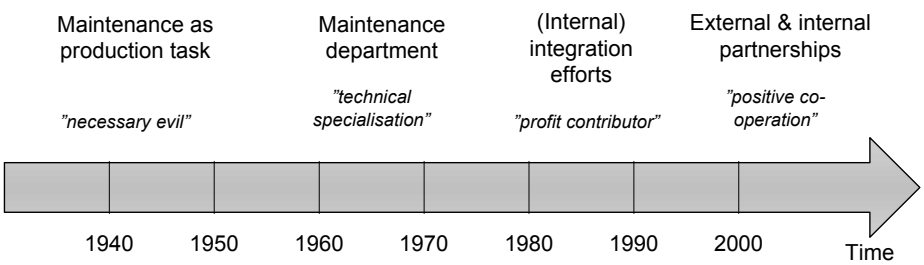

Fig. 10. Evolution of maintenance management (slightly modified from Pintelon *et al.* 1999).

To conclude, maintenance can no longer be viewed as a separate function, but rather a process entity that traverses the various companies of the maintenance supply chain. Figure 11 presents an illustration of maintenance as a service process entity divided to three parallel processes: maintenance, information management, and logistics (see e.g. Piispa 2007). The service process includes activities on strategic, tactical (process control and planning), and operational level.

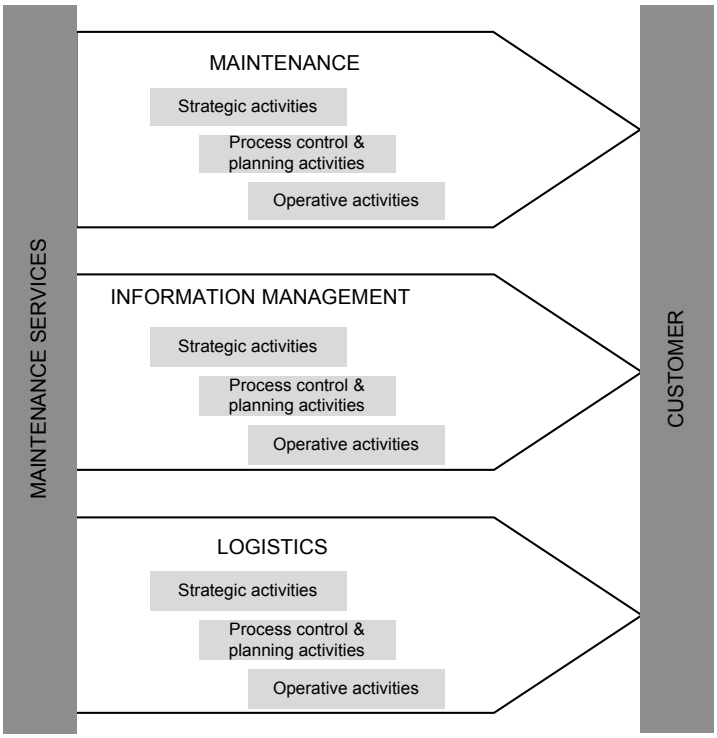

Fig. 11. Maintenance as a service process (modified from Piispa 2007).

4.1.1 Maintenance types

Maintenance work or process can be divided into three different types or levels. Kelly (1997) presents a classification to first-line, second-line, and third-line work. *First-line work* is performed on daily basis and includes mainly emergency/corrective work. *Second-line work* involves deferred corrective work that can be carried out usually within a couple of days and require relatively few

human resources. *Third-line work* necessitates a major shutdown, plant overhaul, capital projects and modifications and creates peak loads at medium-or long term intervals. Another similar classification is introduced by Clamp (1996) categorising maintenance work into three levels. *Level 1* maintenance is executed to keep the plant running and it involves minor repairs, process testing, production scheduling and environmental control. *Level 2* covers activities producing significant change to the condition of the plant, for instance, more detailed inspection and major component replacement that are performed periodically. *Level 3* maintenance necessitates special skills and facilities and contains e.g. overhauls, plant modifications and reconditioning. A third typical classification divides maintenance into

- *corrective* (reactive or failure-based) maintenance (e.g. Paz & Leigh 1994) and
- *preventive* maintenance, which is often referred as use-based maintenance, where maintenance activities are carried out intermittently or based on the amount of machine use (e.g. Gits 1992, Swanson 2001).

Nowadays, a third class, *predictive* maintenance, is often added to this classification and referred to as condition-based maintenance, where maintenance is initiated in response to a specific equipment condition (e.g. Gits 1992, Swanson 2001). The case supply chain maintenance process and the annual overhaul that is specifically examined in this study involve all three types of maintenance activities presented in the classifications above. In annual overhaul, third-line work is typically dominating.

4.1.2 Maintenance as a process

According to Söderholm *et al.* (2007) maintenance consists of four activities: maintenance planning, maintenance execution, functional testing, and feedback. *Maintenance planning* refers to the planning of maintenance execution. *Maintenance execution* needs a maintenance plan, maintenance environment, maintainability of technical systems, maintenance documentation, and the actual availability of time, personnel and resources as its inputs. The third phase, *functional testing*, implies to testing a function of an item in relation to some requirements. This may be done continuously or periodically and testing is also performed after the maintenance execution to ensure that the system has been maintained in, or restored to, the state where it can deliver a required function.

Testing involves activities such as inspection, monitoring, fault diagnosis, and function check-out. Functional testing is an integral activity to maintenance, since in it, the data and information about the actual health of the system is gathered. This data and information is feedback for all the other activities in the maintenance process and should be thus distributed also to the other stakeholders of the maintenance process. Functional testing is in reality the first stage of the maintenance process, generating the inputs to other process stages. The fourth activity in maintenance process is *feedback*. Feedback goes mainly from functional testing to maintenance planning and maintenance execution. Other feedback loops include the feedback from maintenance execution to maintenance planning ascertaining the progress of maintenance execution and feedback from operative maintenance to the stated maintenance objectives, strategies, and policies. (Söderholm *et al.* 2007).

The process view of maintenance supports continuous improvement and continuous risk reduction in maintenance activities. The continuous improvement is governed by the changing requirements of the stakeholders of the maintenance process. The maintenance process can be represented following Deming's (Deming 1993) PDCA-improvement cycle (plan, do, check, act) to emphasise the continuity of the maintenance process and the need for continuous improvement (see Figure 12).

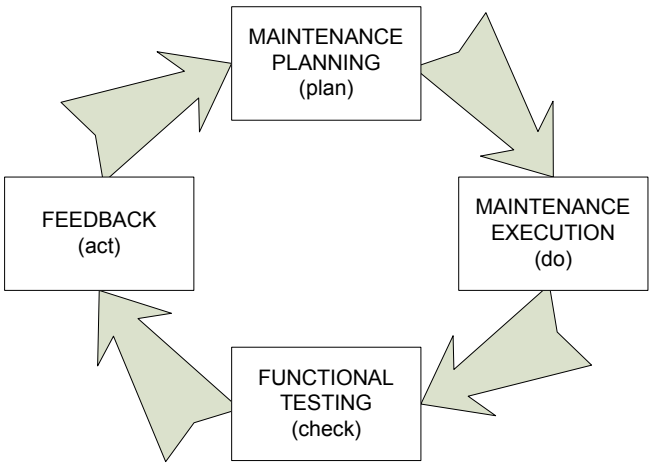

Fig. 12. Maintenance process and continuous improvement (combined from Deming 1993 and Söderholm *et al.* 2007).

Viewing maintenance as a process encourages continuous development and risk reduction in maintenance. Process view assists in defining the stakeholders, demands and risks related to the process. Maintenance has several interest groups that can be internal or external to the process. Production, for instance, is a customer of the maintenance process and procurement may be responsible for sourcing maintenance-related materials and services. Various groups of actors and responsibility areas exist related to maintenance, e.g. mechanical maintenance, electrical maintenance, maintenance-related planning/engineering, etc. The demands and expectations of interest groups may change and changing requirements may bring additional interest groups to the process. (e.g. Söderholm *et al.* 2007).

Maintenance management should be integrated with other functions or processes in companies, such as production and quality management (Garg & Deshmukh 2006). Iravani & Duenyas (2002) have shown that integrating decision-making in maintenance and production brings substantial advantages. Moreover, Jonsson (1999) has emphasised the role of integration of maintenance with other functions in achieving better performance results.

4.1.3 Performance measurement in maintenance

Maintenance of key performance measurements is an essential component of information management system in maintenance, as they provide the link between the current maintenance status and the maintenance objective (Cholasuke *et al.* 2004). Approaches and measures to performance measurement in maintenance have been examined, for instance by Pintelon & van Puyvelde (1997) and Tsang *et al.* (1999). Traditional maintenance performance measures can be divided into three categories (Campbell 1995):

- Equipment performance measures (e.g. availability, reliability, and the overall equipment effectiveness),
- cost performance measures (e.g. costs of labour and materials), and
- process performance measures (e.g. the ratio between planned and unplanned maintenance work, schedule compliance).

These measures, however, have been considered inadequate to form a comprehensive view on maintenance performance and they bring no information about the capability of maintenance to bring value to support the business success of an organisation in the future (Tsang 2002). Thus, use of more strategic

measures has been suggested by Tsang (2002). For instance Balanced Scorecard by Kaplan & Norton (1996) is one strategic measurement instrument that has been applied in maintenance operations (e.g. Tsang 1998, Tsang & Brown 1999, Liyanage & Kumar 2003). Parida & Kumar (2006) suggest measuring the total maintenance effectiveness. The QFD (Quality Function Deployment), known originally as a quality tool, has been applied also in maintenance (Kutucuoglu *et al.* 2001). Raouf & Ben-Daya (1995) and Dwight (1999) suggest maintenance system auditing to be an approach to solve some the problems related to performance measurement. Arts *et al.* (1998) propose utilising maintenance information systems in performance measurement. Internet and development of technologies enable nowadays for instance condition-based maintenance to be carried out electronically (e.g. Wiseman 2000).

Kutucuoglu *et al.* (2001) suggest five general categories for performance measures to achieve a balanced view on maintenance: equipment related performance, task related performance, cost related performance, immediate customer impact related performance, and learning and growth related performance. Parida & Kumar (2006) add two more categories: health safety and environment and employee satisfaction related performance (also Parida *et al.* 2005) In practice, however, it seems to be common, that maintenance organisations use performance measures primarily for operational control purposes. Usually there is no structured process for identifying the performance measures. Typical measures used are financial measures, e.g. operation and maintenance costs and equipment or process based measures, such as equipment availability, labour productivity, and number of incidents caused by in-service failures. (Tsang *et al.* 1999).

Tsang (2002) highlights two factors that pervade the strategic dimensions of maintenance management and apply also to the interfaces with external maintenance partners: human factors and information flow. According to Tsang (2002), an understanding of the behaviour at work and the conditions for enhancing group effectiveness will produce better organisational designs and create commitment. He further continues that information can influence people's behaviour (and thus the performance), when a performance management system communicating the strategy and emphasising a balanced approach is in place.

4.1.4 Maintenance process in the focal company

In the focal company the maintenance process has been divided into three core processes:

- *Strategic maintenance planning*, which embodies determining the business goals, defining the objectives of maintenance so that they are in line with the objectives of production, and defining the areas of focus and activities required.
- *Continuous development of the operations* comprises of positioning the current performance, analysing the results and determining corrective actions, and measuring/monitoring the progress and addressing deviations, when they occur.
- *Continuous maintenance of the production* involves monitoring the condition of the equipment, planning the maintenance work and reserving the resources (materials and personnel) needed, and implementing the maintenance work, documentation, and control.

The continuous maintenance of the production is further divided into *proactive, preventive, and corrective* maintenance. Proactive maintenance includes monitoring the condition of the production equipment, analysing the results and development trends, and predicting the time to failure. Preventive maintenance involves the planning of preventive maintenance actions, implementing the preventive maintenance work, analysing the results (failures), and updating the software accordingly. Corrective maintenance consists of the planning of required corrective maintenance work, executing the corrective maintenance work, and determining the root cause for the failure and corrective actions needed.

Once a year there is a longer period of annual overhaul shutdown (1–3.5 weeks depending on the production line) during which larger-scale reparations are performed. The shutdown is typically timed for July-August. For some production lines additional shutdowns are organised, for instance, in turn of the year. Moreover, weekly shutdowns in production are arranged for the necessary maintenance work to be performed. Finally, there is the unplanned, corrective maintenance work, which can not be fully avoided, although the company has understood that moving from reactive maintenance to more proactive maintenance will result in improved safety and lower maintenance costs.

There are several ways to implement the maintenance work in the focal company. The staffing approach taken is a combined in-house/contract staff (see

e.g. Wireman 1990). In-house staff performs most of the maintenance tasks, but external contractors are used to perform certain tasks. Majority of the FC's maintenance activities are managed in-house. In-house maintenance organisation is divided into narrower responsibility areas, for instance, according to the different production lines and the type of maintenance work (mechanical, electrical, automation). There is a separate repair workshop in-house that takes care of repairing the spare parts. Purchasing is responsible for sourcing the spare parts and the selection of service providers based on quotations. The transportation and inventory management of spare parts has partly been outsourced (VMI, i.e. vendor-managed inventories).

External service providers (contractors) are used mainly on short-term contract basis. A few longer-term contracts have been made with mechanical maintenance service providers so that they are responsible for a certain part or certain repairs of a production line. Representatives of these external service providers may be located at the focal company's facilities to be able to monitor the conditions and react quickly if a failure occurs. In annual overhaul, however, mechanical maintenance service providers are mainly used on contract basis for shorter-term periods and contracts are issued through competitive bidding. Rental work force is also used temporarily during the annual overhaul shutdowns, as there is a peak in resource needs. The planning work related to maintenance is purchased from engineering offices based on timework (hourly rates) agreed in longer-term (e.g. one year) contracts.

The highest peak for use of external service providers occurs during the annual overhaul. For instance, in hot strip mill, there may be around 600 external employees during the annual overhaul coming from around 20 different companies. This study focuses on the mechanical maintenance service providers and engineering offices providing maintenance-related planning services. However, there are other actors and some support services involved in the annual overhaul as well. For instance, material suppliers for parts, tools, chemicals, etc needed, crane/lifting service providers, sanitation service providers, and information system service providers. Figure 13 outlines the scope of this study as a part of the overall group of actors in the focal company's maintenance supply chain.

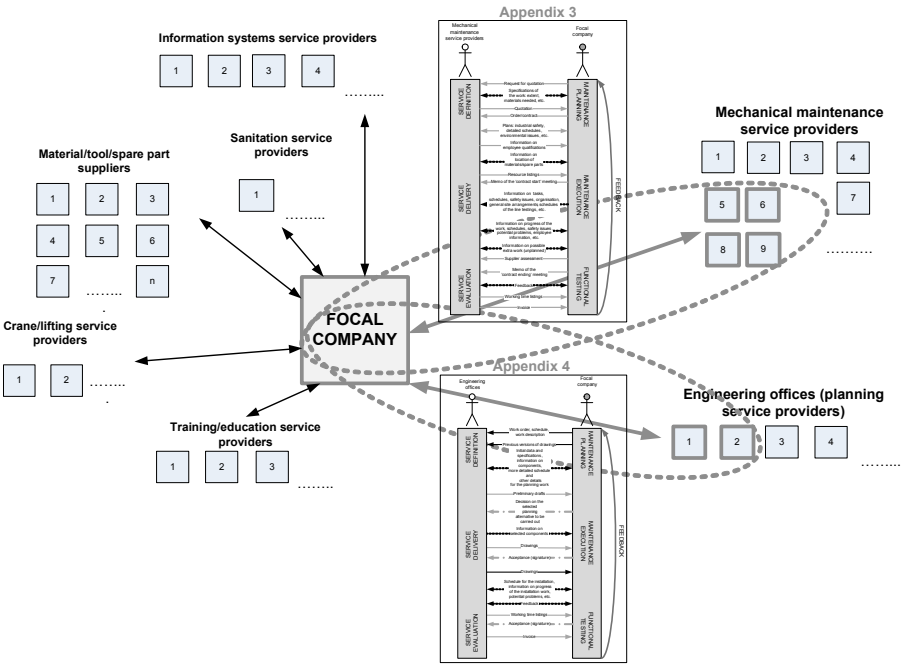

Fig. 13. The case maintenance service supply chain of this study: the actors and information flows covered.

Annual overhaul

The timely scope of the process phases related to annual overhaul in the FC, including the planning, implementation, and control, is almost one year. The preliminary preparations for the next year's annual overhaul are started already when the previous overhaul has been finished. Regular planning meetings, in which the schedules, tasks, and resources are planned, are started about half a year before the annual overhaul shutdown will take place. In-house maintenance personnel and representatives from the repair workshop, production, and purchasing are participating the meetings. Some critical spare parts may need to be purchased already more than half a year before the overhaul occurs and some spare parts may need to be repaired as well. Funding for the next annual overhaul is reserved for the budget already in the previous autumn.

The actual implementation of the annual overhaul lasts typically 1–3.5 weeks pro each production line. Some reparations can be performed in parallel with the reparations of other production lines.

The reporting, evaluation, and control activities performed after the actual reparations have been done will take time from one week to a couple of months. Cleaning the facilities is typically done the week after the reparations have been completed. In September (1.5–2 months after the reparations) there will be a closing session organised to summarise the reparations done and to give feedback to the actors involved in the annual overhaul.

Common problems during the annual overhaul

During the annual overhaul shutdown, typically some common practical problems occur. These problems can either partly or entirely be attributed to deficits in information sharing between the different actors in the maintenance processes of the annual overhaul. The problems may generally be related to scheduling, sequential working order, work instructions or use of support services, such as cranes or lifting equipment.

Time is lost due to waiting for delayed material (spare part) deliveries, materials being out of stock, wrong materials having been planned, ordered and/or arrived, extra time needed to find out the location of materials and/or identify them, and quality problems in materials which make them unusable. If one craft is waiting for the missing materials it may cause delays in the other crafts' maintenance activities, as the activities typically need to be performed in certain sequential order. It may even be that some less relevant tasks are then omitted from the schedule due to these delays. Similar typical material-related delays in maintenance have been identified also by Wireman (1990).

The maintenance work is done in shifts, and thus if information is not transferred among the crafts performing the various shifts, same work may be done twice and time lost. Moreover, if there are delays in some tasks, the effect of delays may accumulate during the annual overhaul due to the predetermined sequential order of the tasks. Negligence in sharing information to maintenance employees (e.g. regarding safety instructions) may also occasionally lead to near accidents, delays, or rescheduling of the maintenance work. Sometimes drawings are not properly updated and this causes additional work or delays and tightening schedules in the maintenance work. If the actual workload turns out to be greater than anticipated, extra shifts and additional work force may have to be arranged.

The planning work may also be delayed if the employees performing it receive incomplete or misguiding initial data. Something may be misunderstood and in the worst case the planning work may fail entirely, which of course leads to difficulties in other related maintenance tasks during the annual overhaul. Wrong component choices, making the same mistakes several times, and unnecessary work deriving from deficits in information sharing can cause problems in the planning services. Sometimes the time for planning work is so restricted, that there is only time for a temporary quick fix solution and not for a thorough planning work.

Typically acute additional maintenance objects are detected during the annual overhaul which may cause disturbances in the sequential order of work or the planned schedule. This unplanned work affects both the planning services and mechanical maintenance services.

Maintenance information systems

The various interest groups and diverse ways to implement the maintenance work naturally cause divergent requirements for information systems and integrating information in the maintenance process. The maintenance information system at the focal company is rather a production facility service system, which contains also maintenance-related information. The current system has more than 2000 users, a large majority of them being in-house users. To describe the technical scope of the system, some key figures are presented:

- 95000 number codes exist for individualising the devices,
- there are 520000 maintenance objects,
- the number of maintenance tasks is around 12700, and
- approximately 30000 disturbances (including also the minor ones not causing a stoppage in the production) are registered yearly.

The applicational scope of the maintenance information system includes the management and control of maintenance, maintenance task management, inventory management (spare parts, tools), equipment management, and resource management (internal and external). In the interviews, the system was described to entail requests for spare parts, work orders, job entry and planning, repair history data, some information on competence of the personnel, and rough schedules for maintenance tasks.

The maintenance information system of the FC is difficult to use for new users, it has deficits in the functions of scheduling and resourcing the maintenance activities, and it does not offer adequate possibilities for documentation of the maintenance activities. The system will in the near future be replaced by a new one that will be easier to use and link with other systems. The supplier of the new system has been selected. There is a challenge of getting all maintenance-related information into one place from separate systems and archives. Still much information exists only in personal notes and files of the FC's personnel and not in the systems. The new system is believed to lead, through better integration of information, to the following benefits:

- reducing the amount of manual work,
- improving the availability of information (quicker access to information),
- improving the quality of information, and
- enabling the adoption of a larger extent of knowledge (e.g. to support decision-making).

Several development needs have been identified for the maintenance information system in the focal company. The increasing requirements for delivery reliability and production flexibility have increased the need to develop the dynamics of controlling maintenance and optimisation tools used. The possibilities to utilise information related to monitoring the equipment condition and equipment use should be developed to support fast decision-making in controlling the operations. The maintenance information systems need to be modular and flexible enough so that they can be developed to respond to the changing requirements set by processes. The integration needs for the maintenance information system in the focal company include, for instance, the following:

- Financial administration: e.g. invoice handling, cost awareness.
- Human resources management: e.g. personal data of the personnel, competence of the personnel, organisations and responsibility areas.
- Salary payment: e.g. registration of working hours, costs of the maintenance tasks.
- Purchasing system: e.g. requests for order, acknowledgements of receipt, cost data.
- Inventory system: e.g. information on materials, inventory status, uptakes from the stock.

- Production information systems: e.g. production output, operating time, and information on disturbances.
- Planning system: e.g. retrieval of drawings, connections between devices/equipment.
- Document management: e.g. instructions/service manuals, safety notices.
- Maintenance support systems: e.g. operational reliability software, schedule management.

In addition to the maintenance information system there are several other systems or electronic data archives used in the FC maintenance process. There is an archive for drawings of the production equipment/devices. Also a separate disturbance registration system for the production line for hot rolled plate and strip products is used. A separate system for doing a safety review for maintenance assignments is in use. In hot strip rolling two other systems exist, in which failures/disturbances are registered by the production personnel. Furthermore, the following software/tools are utilised related to the annual overhaul: MS Office tools, planning tools for scheduling, AutoCAD, strength calculation software, a separate tool for reporting industrial safety issues such as near accidents and work accidents, and various working time registration systems. Even if documents are created with these tools, they may be shared in paper-form or both electronically (as an attachment of an e-mail) and in paper-form.

Measuring the performance

The focal company has a set of production-related measures in use to assess the performance of maintenance work. These measures include the operating time ratio of production lines, disturbance rate (for each production line as a percentage), production quantities, and quality-related measures such as the amount of scrap and rejection rate. Some condition monitoring measurement data is also gathered to determine the timing of preventive maintenance work. The total costs of the annual overhaul shutdowns are reported, but not on very detailed level. Related to industrial safety, the number and details of near accidents and work accidents are reported. Feedback concerning the success/failure of the maintenance work performed is also received from the personnel operating the production lines.

In the FC, the maintenance work completed during the annual overhaul compared to the work that was planned to be completed is perceived as one

measure describing the success of the annual overhaul. Compliance to schedules is monitored daily (or twice a day) during the annual overhaul. The actual realised schedule is, however, not properly documented and stored after the annual overhaul shutdown is over. Thus, the schedule can not be properly utilised in planning the following year's shutdowns.

The mechanical maintenance service providers generally need to provide the FC with a list of working hours and list of materials or spare parts if they are included in the service. In case of larger contracts, an enquiry on customer/supplier satisfaction in written form is made based on the FC's quality system. MMs monitor their own schedules during the maintenance work. However, also in MMs the information on realised schedules remains in employees personal notes and is not necessarily documented formally. MMs also report possible near accidents and accidents in their own systems or paper-based archives. Feedback is given internally to service provider's own employees after the annual overhaul. Some cost accounting may be done to estimate the profitability of contracts and to assist estimating the costs of work for the tendering in future. The realised labour input is also documented.

Engineering offices measure and document the costs of and the time used for the planning work. One of the two EOs documents some factors affecting the time and cost (number of drawings, whether strength calculation is involved, time management, documents related to the work) in their cost accounting. However, the FC does not give EOs feedback on the accuracy of the original cost estimate of the planning work compared to the realised costs, which might be of assistance for EOs in planning the future work and resources. EOs get mostly only informal feedback from the FC, but FC also gives the EOs feedback on the persons involved in the planning work in written form.

To conclude, the case supply chain companies have their own performance measures and only some performance data is shared between the companies. Measurements emphasise the time and cost aspects, and not all performance data is accurately or adequately documented. The scope of performance measurement remains thus quite narrow. To give one example, the efficiency and success of scheduling and resourcing is not systematically measured in the case supply chain. It could be measured e.g. through the amount of effective maintenance work (wrench time) and compliance of schedules (e.g. Järviö 2007).

4.2 Applying the elements of integration in the case supply chain

All six elements of information integration can be considered relevant in the case supply chain. Different elements may, however, be seen as serving different purposes or functions in the case supply chain companies. The time-related issues and information attributes are related to the objectives of information management in the maintenance process and maintenance service processes of the case supply chain. Information management is understood to aim at information availability, speedy and real-time access to information, and information quality, such as reliability. Common problems during the maintenance process occur typically as 'delays' referring to the time dimension. The maintenance services are also bounded in their time utility, as the service capacity that remains unused can not be stored and utilised later.

The elements of information sharing practices (describing the extent and frequency) and information technology use are rather seen as the practical development means to achieve the objectives related to information attributes and time element in information sharing. Most of the information sharing problems in the case supply chain are clearly attributed to the deficits in current information systems and technologies and inconsistent and inadequate practices or procedures for information sharing. Majority of the practical development ideas to facilitate information integration in the case supply chain were also formed around the systems and procedures and their more extensive use among the case supply chain actors.

Due to the high degree of human involvement in the maintenance process, achieving the objectives of information management is also highly dependent on how the co-operation between different individuals and organisations functions in the process interfaces. In the case supply chain this has a twofold meaning: enough knowledge on the processes must be gained to control the interfaces, and a collaborative foundation must be built to ensure the smoothness of co-operation. Processes and collaboration are seen as some kind of supporting structures for the information sharing. The collaborative issues were constantly raised up by the company representatives during the case study process. Regarding the processes and activities, the case supply chain companies seem to have a relatively clear picture of their own tasks. However, linking them with the activities of other groups of actors is challenging. The need for gaining a comprehensive view on the activities during the annual overhaul and persons responsible for them was highlighted in the case supply chain. The roles and responsibilities of people

performing the activities sometimes remained unclear and complicated the information sharing between various activities. Moreover, the current information systems were considered inadequate to support all the essential activities in the maintenance process.

To conclude, all the six elements of information integration were considered to have at least a moderate, but mostly high importance in developing information integration in the case supply chain. Table 6 summarises the role of integration elements and gives examples of the indicators of their occurrence and importance in the case supply chain. The indicators have been picked out from the discussions with case supply chain informants during the research process.

Table 6. Importance of the elements of information integration in the case supply chain.

Element of integration	Purpose / function	Indicators
Processes and activities	supporting structure	'unclear responsibilities', 'overlapping tasks', 'several interest groups', 'the maintenance entity divided in small pieces', 'people are scattered', 'crisscross information sharing', 'a general view needed', 'links to several interest groups', 'large number of various actors'
Information technology use	development tool	'information dispersed in systems', 'access to systems could be extended', 'need for an interface to information systems', 'access to systems needed', 'should be done in electronic form', 'more communication through e-mail'
Information attributes	objective, orientation	'reports reliable, but not accurate enough', 'more consistent and accurate reporting', 'graphical presentation preferred', 'presentation form should be improved', 'information availability', information reliability', 'information quality', 'which of the documents is the latest version?'
Information sharing practices	development tool	'trying to remember how things went', 'more consistent reporting', 'more systematic informing', 'weekly interaction', easy to visit', 'daily meetings', 'virtually daily phone calls', 'systematic method for collecting experience-based knowledge', 'information shared in informal discussions', 'varying practices', 'more consistent practices needed', 'procedures vary depending on the actors', 'meeting practices', 'more regular meeting practices', 'information only through discussions'
Collaborative foundation	supporting structure	'people know each other', 'trusting relationship', common vocabulary', common language', 'network', 'mutual understanding', 'common rules', 'contractors can usually be trusted', 'challenge to form long-term partnerships', 'commitment of people to share information', 'finding the resources needed', 'scarce resources'
Time-related issues	objective, orientation	'dead-lines of reporting', 'too tight schedules', 'speedy and real time access to information', 'reaching the right person can take time', 'delays in schedules', 'finding the information can take time'

4.3 Applying the model on contextual factors in case supply chain

The case supply chain involved two types of service providers: mechanical maintenance service providers and engineering offices providing maintenance-related planning services. The dyads between the mechanical maintenance service providers and the focal company are called MM-FC dyads and the dyads between the providers of maintenance-related planning services (engineering offices) and the focal company EO-FC dyads (MM stands for mechanical maintenance, EO for engineering offices/maintenance-related planning and FC for the focal company of the case supply chain). The four MM service providers are local, small to medium-sized companies. The service contracts are mostly gained through competitive bidding and there are only a few areas where long-term contracts have been made. The two engineering offices providing maintenance-related planning services are small local units. One of them is a part of a medium-sized national engineering company. The EOs have longer-term contracts with the FC. They are also located close to the FC and have been co-operating with it for a few decades.

Focal company representatives assessed all maintenance-related services in workshop 2 along a few selected dimensions. The complexity or degree of customisation of services was considered as well as the closeness of the relationship between the FC and the service providers. Service providers' perception on the closeness of the customer relationship was also discussed in the interviews. The level of interdependence between service providers and the focal company was estimated based on the replacability of the service providers (which was also discussed in the workshop 2) and the importance of the customer to service providers (interviews). The type of contracts with and selection criteria of the service providers elucidated the prevailing order winners in the two different service dyad categories.

The uncertainty in volume of services was assessed based on the interview questions dealing with services typically provided to the FC and services provided during the annual overhaul under examination in this study. In pursuance of answers to these questions the case supply chain informants also typically commented the uncertainty aspect in general. The question of uncertainty came also up in the workshop discussions. The type of the service provider resources was clarified in the structured interviews by inquiring the service providers, how important customer the FC is and whether they have other

major customers and what kind of customers to find out if the resources are mainly focused to serve the FC.

4.3.1 Contextual setting in MM-FC dyads

In MM-FC dyads the level of interdependence can be described as low. It was clearly stated in discussions with case companies, that mechanical maintenance service providers are rather easily inter-changeable and easily replaceable as there are several similar local service providers that have already gained knowledge on the FC's operations. The interdependency between the FC and MMs may increase in the near future, as the maintenance personnel in the FC is aging and there is assumed to be a retirement wave. Lack of competent workforce and inadequate methods to transfer the tacit knowledge from the current employees to the next generation of employees may lead to a situation in which FC may be compelled to seek qualified workforce through external service providers and becomes thus more dependent on the MMs.

The mechanical maintenance service providers are providing mainly routine maintenance services, where the complexity of the services is low. There is only limited need for customisation in the services. Typically, same service providers may have gained the same contracts for several years in a row, although contracts are admitted based on the bidding process. Thus, some routines related to the assignments have been formed.

The closeness of the customer relationship between the FC and MMs is described as loose to moderate, although on the whole these companies have been supplying maintenance services for the FC for years. The service providers perceive the relationship closer than the FC, probably because they are more dependent on the FC. Two of the four MM service providers reported that they have recently established a three- of five-year contract in some area of maintenance with the FC. This will in the future in all likelihood lead to a closer relationship with the FC.

As there are several MMs who have co-operated long with the FC, a mutual conception of the acceptable quality criteria for the mechanical maintenance services already exists and is expected by default. Moreover, as the mechanical maintenance services are routine-type services, cost is the major order winner when purchasing them.

The MMs in the case supply chain are shared resources supplying services to other customers beside the FC. However, the MMs consider the FC a major

customer and have provided services to it for years. Service providers estimate that even 80–90% of their revenues (or respectively revenues of the local unit) come from the business done with the FC. There are plans in the FC to move into longer-term relationships also with (selected) MM service providers, which would then increase the buyer focus in MM-FC dyads even more, as several year contracts with MM service providers would be made and certain resources devoted to the FC's use.

The level of uncertainty in the volume of mechanical maintenance services is classified as medium. Due to the competitive bidding procedure, the service providers can never be certain of the contracts they will get each year. If no contracts are gained with the FC, it may be difficult for service providers to reallocate the already reserved resources to some other customers' use at short notice. The FC also first endeavours to carefully allocate its internal maintenance resources and only then resorts to external resources, so the volume of external services purchased may vary yearly. Moreover, the service capacity is unevenly distributed, with the peak in demand for the capacity being during the annual overhaul in the summer.

A summary on the status of the contextual factors in MM-FC dyads and the expected levels of integration is presented in Table 7. Based on the status of contextual factors, the expected aggregate level of integration in the MM-FC dyads is level 1, i.e. the transparency level.

Table 7. Contextual setting and expected level of integration in MM-FC dyads.

Contextual factor	Status in MM-FC dyads	Expected level of integration
Level of interdependence	low	1
Complexity/degree of customisation in services	routine/low	1
Closeness of the customer relationship	loose-moderate	1–2
Type of resources	shared, but leaning more towards buyer focus	2
Uncertainty in volume of services	medium	2
Order winning criteria	cost	1
The aggregate level of integration		1

4.3.2 Contextual setting in EO-FC dyads

In EO-FC dyads, interdependence is at medium level. Engineering offices are not that easily replaceable as there are only few local actors and knowledge on customer's facilities and manufacturing process is of advantage when providing the planning services. Proximity is an essential factor in planning services, as it makes especially the service definition phase easier, and thus supplying the planning services from local actors is preferred.

The complexity of planning services is described relatively high as the assignments are often unique and the experience from previous assignments can not necessarily be deployed directly in the planning tasks.

The service resources in EO-FC dyads are fairly focused, as the engineering offices report that about 80–90% of their resource capacity is used by the FC. They have, however, also some other large industrial customers. The buyer focus is, nevertheless, somewhat more intensive in EO-FC dyads than in MM-FC dyads of the case supply chain.

The closeness of the customer relationship between the FC and EOs is described as loose to moderate. Engineering offices are located close to the FC and have been co-operating with it for a few decades. The EOs have longer-term contracts (one year) with the FC than the MMs and the FC reserves a certain amount of resources from the EOs for its use yearly. Nevertheless, the relationships have not developed to partnership type of close relationships yet.

Buying of the planning services is based on the quality and flexibility (delivery speed) of the services rather than cost. The assignments are typically, at least to some extent, unique. It often depends on the preliminary design data and specifications, how smoothly the planning assignment can be carried out and whether some changes and adjustments have to be made later. In fact, the cost of an assignment is undoubtedly seldom known exactly in advance and is not a determining factor. Each assignment is charged afterwards from the FC based on reported working hours and agreed hourly wages.

The uncertainty in the volume of planning services can be defined to be at medium level. The service volume can not be exactly predicted, but some of the predetermined larger project-type of planning assignments can of course be planned and launched well in time. Moreover, the uncertainty in volume has been reckoned with, as the capacity from engineering offices has been reserved and thus also the EOs experience less uncertainty regarding the demand of the services and their resource planning.

Table 8 summarises the status of the contextual factors and the expected levels of integration in EO-FC dyads. Based on the contextual setting, the expected aggregate level of integration in the EO-FC dyads is level 2, i.e. the commitment/coordination level.

Table 8. Contextual setting and expected level of integration in MP-FC dyads.

Contextual factor	Status in MP-FC dyads	Expected level of integration
Level of interdependence	medium	2
Complexity/degree of customisation in services	relatively high	2
Closeness of the customer relationship	loose-moderate	1–2
Type of resources	close to buyer focus	2–3
Uncertainty in volume of services	medium	2
Order winning criteria	quality/flexibility	2–3
The aggregate level of integration		2

4.3.3 Summary on contextual factors

The propositions regarding the effect of contextual factors on the level of integration in service supply chain dyads (Figure 4) was deployed to analyse context of integration in the case supply chain dyads. Six variables defining the service supply chain context for a dyad were included in the analysis: level of interdependence, complexity or degree of customisation in the services, closeness of the customer relationship, uncertainty in service volume, type of resources, and order winning criteria. Based on the analysis of contextual factors, level 1 integration is assumed to exist in MM-FC dyads. EO-FC dyads, on the contrary, are likely to reach the second level in integration based on the contextual background. The difference in expected levels of integration between the dyads can be attributed to the higher interdependence, greater service complexity and higher emphasis on flexibility of services inherent in EO-FC dyads. Figure 14 illustrates the contextual setting in the case supply chain dyads.

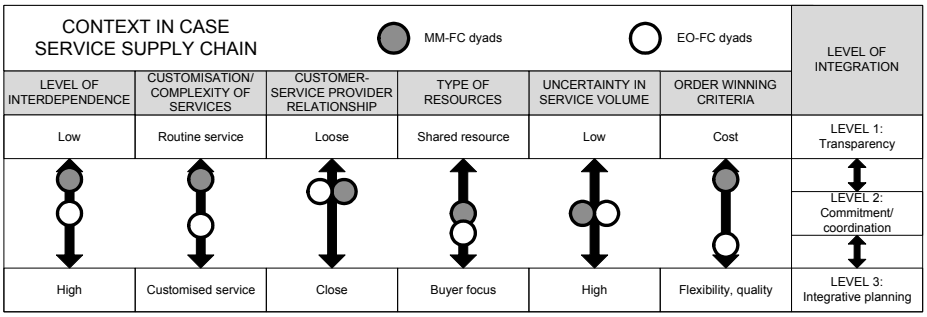

Fig. 14. Summary on the status of contextual factors in MM-FC and EO-FC dyads.

4.4 Applying the levels of integration in the case supply chain

To roughly estimate the current extent of information integration in the case supply chain dyads, the integration levels presented in the theoretical part and their operationalisations along the six information integration elements in Table 1 were used. The analysis was again done separately for MM-FC dyads and EO-FC dyads. Moreover, extracts from the interviews conducted in the case companies have been included in the analysis to provide support to the arguments presented.

4.4.1 Level of integration in MM-FC dyads

Information sharing in MM-FC dyads occurs, as described, in three phases: before, during, and after the annual overhaul. Information sharing during the annual overhaul, i.e. in the maintenance execution phase (service delivery), is the most challenging and critical phase as there is simultaneously a large number of actors dispersed in the FC's production facilities, working in several shifts under various supervisors, and they all should receive timely information as fast as possible. The most critical information to be shared in MM-FC dyads includes the schedules, the content of the maintenance work, safety issues, information on the location of materials and spare parts, and feedback. A more detailed description on the information flows in MM-FC dyads is presented in Appendix 3.

Processes and activities

The planning of maintenance activities related to the annual overhaul is done internally in the FC and information on resource needs and schedules are then

forwarded to MM providers. The service providers then plan their own schedules and resources in more detail and inform the FC on them.

> *"At that point, when the information comes….the contracts are indeed such that the FC does not necessarily let us know very early who gets the contracts…. it is always left quite to the last minute……But they give us some hints…..Let's say about two three weeks earlier (before the annual overhaul) we will start thinking of the resourcing, etc."*(The interviewee from MM1)

Deficits in internal integration of the FC (between maintenance, purchasing and production etc.) seem also to be reflected on the integration with MMs. For example, service providers generally need materials for their maintenance work. These are usually procured by the FC and it may be difficult to get information on the delivery times and location of the materials. Materials often arrive late or can not be found and cause delays or even cancellations of maintenance work. Basically, there are no clear integration links between the different activities of maintenance among the MMs and the FC. One example describing the lack of comprehensive view on maintenance process is , that it is not necessarily known, which service providers' employees have been performing certain maintenance tasks. Sometimes the service providers do not remember this either, if they have not documented the roles and responsibilities internally. Moreover, the contact persons of certain responsibility areas and their contact information are often not clear to the employees during the annual overhaul.

> *"Contact persons responsible for certain areas could be better defined"* (The interviewee from MM3)

Furthermore, work descriptions are only available for some maintenance tasks, which indicates, that the maintenance activities in the FC have not necessarily been defined on a detailed level.

> *"If there is a task that you have not performed before, it would make it easier for us if there would be some information available on how it (the task) has been done earlier."* (The interviewee from MM2)

When assessing how well the information sharing covers the activities of the maintenance process, the most integrated part of the process seems to be the execution of the maintenance work. By contrast, there is absence of integration to be seen in the maintenance planning and control and feedback (functional testing) activities. For instance, the reporting after the annual overhaul is done mostly

internally in the supply chain firms. The FC gets some information (e.g. working time reports and information on completed work) from MMs. However, the potential to collect and utilise data from the MM service providers still offers many untapped opportunities, especially in longer-term planning of the service operations and the maintenance process. Specifically deficits in sharing feedback information were brought up among the company representatives. Particularly the lack of recognising success in the maintenance work (positive feedback) and giving feedback regarding the results of functional testing to service providers is criticised. This kind of feedback could facilitate the control and planning of maintenance activities in the future. Positive feedback could also add the work motivation and commitment of the MMs.

> *"Yes, we get the feedback from FC……if something goes wrong we will hear about that. It is just a part of the human nature that it would be nice to hear some positive feedback as well."* (The interviewee from MM3)

Information technology use

The MMs do not have any access to the FC's information systems used in the maintenance process. The FC does not have any access to MMs' systems either, although some of them have internal systems in use. However, both the representatives of the FC and some of the service providers feel that the MMs should be given a partial access to the FC's maintenance information system(s). In the current situation service providers' employees are allowed to access a few minor information systems (e.g. the system for doing a safety review for a contract) upon request as they are in the FC's facilities, but not independently or from their own facilities.

> *"We do not have access to them (to the FC's information systems). They (the FC) are protecting them quite carefully."* (The interviewee from MM2)

Still much information, also internally in FC, only exists in personal notes and files of the employees and not in systems. Although some information that is shared with MMs exists in systems, FC still shares it only informally.

> *"It depends whether they (the FC's employees) have the information in their own (the FC's) information system."* (The interviewee from MM2)

Electronic information sharing is restricted to e-mail use. As there are no information systems shared between the FC and MMs, the quality and availability of information may suffer and the variety of information that can be shared is limited. For new employees in MM service provider companies getting access to the information needed may be complicated, as information can not be accessed through one single system, but rather through personal contacts and even then the information often needs to be retrieved from several databases or systems by a FC's employee.

Information attributes

Information sharing in MM-FC dyads is mainly done in paper-form or informally (telephone, meetings, and discussions). On the other hand, e-mail is used increasingly nowadays. The MM service providers need to acquire information that only exists as tacit knowledge when defining the work for the quotation and also during the actual maintenance work. Typically also unexpected extra work and problem solving situations come up during the repair work, which also requires informal information sharing and the exploitation of tacit knowledge.

> *"There are sometimes, or actually always, some technical questions to present. They will be negotiated with the FC's supervisors. I see it as the only way to do it. The problems are such that they can not be written on a paper. They should be (solved) there. They are so complicated."* (The interviewee from MM1)

Same information may be shared in various forms which complicates the information sharing. Generally, the need for informal information sharing seems to result from the lack of commonly agreed structured procedures for information sharing and the dynamic nature of the maintenance process. The form of information causes some problems: for instance, viewing drawings three-dimensionally may be impossible for the MM service providers.

The quality of information is generally perceived adequate, but the low rate of IT use and diverse locations for information deteriorate the quality. Not all information is updated in the systems, some documents might not be stored at all and some information only exists in the FC's employees' own notes in various formats and extent.

> *"I doubt if anyone actually updates any information on the computer at that stage (during the maintenance work)."*(The interviewee from MM1)

The version management of documents should be improved. One example describing the situation is the lack of a template for reporting on the completed maintenance work, which leads to a variety of forms of reports with varying degrees of completeness of the information. Thus, the rest of it needs to be memorised; if some missing information is later needed the employees need to dredge it up.

Actors in MM-FC dyads feel that they get the information they need if they only know from whom or where to ask. Yet, information availability forms a problem in MM-FC dyads as the information needed is not available to service providers from information systems and its availability depends on the possibility and willingness of the FC's employees to share it. Especially, difficulties in reaching the right persons and the variation in the presentation form of information may cause problems in the availability of information. New employees might not know from whom or where to get the information needed.This problem is particularly inherent in the MM-FC dyads.

Information sharing practices

Although company representatives felt that some patterns for information sharing have been formed during the long co-operation, they admitted that information sharing practices may vary depending on the persons involved.

> *"It (the information sharing) is probably partly person dependent. And it depends on the extent of the task at hand. If it is a smaller task it will just be discussed with the supervisor."* (The interviewee from MM1)

The practices include certain meeting practices between MMs and the FC. The degree of informal information sharing is very high in MM-FC dyads. The large amount of tacit knowledge is a complicating factor and more effective ways to share and document it should be developed. Overlapping practices for sharing the same information (e.g. schedules) are in use. Some of these might be eliminated to simplify and rationalise the information sharing. Some information sharing practices (such as regular morning meetings) only cover the personnel of the FC and information is then forwarded to service providers informally through work supervisors of the FC, who are the main link to information for MMs during the

annual overhaul. This complicates the information flow and leaves a possibility for human errors. Lack of common procedures and shared systems for information sharing clearly restricts the quantity of information shared.

The frequency of interaction in MM-FC dyads, then again, is quite high due to the close location, personal contacts and the need for retrieving tacit knowledge from the FC's personnel in many phases of the maintenance work. The company representatives also consider the regular interaction essential and often prefer checking some information, e.g. schedules, through personal phone calls.

> *"It is just that we meet with these people (at the FC) weekly. So we are very much in contact with each other and we have the experience of decades and that also shows that we have understood each other well."* (The interviewee from MM4)

Collaborative foundation

All four MMs are located close to the FC and have a long history of co-operation with the FC, even though the co-operation in MM-FC dyads is mainly based on short-term work package contracts and competitive bidding. The number and scope of contracts with each service provider during the annual overhaul varies yearly. It became evident in the interviews that longer-term co-operation with the MM service providers would create more commitment and provide more incentives to develop information sharing.

Ensuring the right amount of resources to perform the services is challenging, as the annual repairs take place in the summer holiday season with demand peak for services and also other large industrial customers have overlapping maintenance projects. It would be important to share resource information at some level in MM-FC dyads to allocate the scarce resources more effectively.

Based on the interviews, the level of trust in the MM-FC dyads can be described as moderate. Companies have worked closely for years or decades; employees know each other personally and feel that problems or sudden changes can be easily managed. One example demonstrating the established trust is that if additional work for MMs emerges during the annual overhaul, the work is performed and the payment is settled afterwards when the hectic period of annual overhaul is over.

> *"It is stated in the contract that every change should be agreed with the FC in written form. But it is also in written form even if it will only be documented afterwards. There is usually not that much time for the paper work. It is jus agreed (with the FC). But it is a question of trust then. But if you have built the trust during the decades it also works like this."* (The interviewee from MM4)

Service providers' employees are also allowed to move freely inside the FC's facilities. However, a fear of information misuse still exists and thus not all pertinent information and information systems are shared with MMs. The common goals in the case supply chain (MM-FC dyads) seem to be mainly on operational level. The main target is to complete the agreed maintenance work in time. No common performance measurement system between the MMs and the FC exists. MMs have their own information systems or files for reporting, for instance, costs, person hours and resource needs for a specific task or part of the contract. MMs are evaluated according to the quality system of the FC, at least in case of larger contracts. Otherwise possibilities for the service providers to give feedback to the FC and receive it are limited and feedback is mainly given informally, if given at all.

Time-related issues

The company representatives in MM-FC dyads feel that the information lead-time is acceptable and all necessary information can be received if they know from whom to ask or where to look. However, due to the high degree of informal information sharing and the utilisation of tacit knowledge, which often necessitates reaching certain persons, the lead-time for information sharing in MM-FC dyads can be prolonged. The lead-time could be easily cut if IT were used more intensively in the MM-FC dyads and thus the person dependency reduced.

Some flaws in the timing of information sharing were also revealed. For instance, the MM service providers would prefer receiving the information on schedules and resource needs earlier to gain more time for their own planning. The FC could also thus receive, for instance, detailed information on the resources (lists of employees attending the maintenance work) from the MM service providers earlier, which also was a need expressed by the FC interviewees. Changes in schedules, resources, etc. and the latest information on safety issues

should ideally be available to all MM service providers in real-time. Now there is often a delay, as this information comes informally through the FC's work supervisors.

> *"Of course, if we could get access to the data base (of the FC) to see even the certain work entity….Even just the schedules telling when there will be an overhaul on which area (production line). That way the information would at least be timely. The paper versions are not updated so quickly."* (The interviewee from MM3)

Summary on integration levels

Table 9 recapitulates the current levels of information integration along the six integration elements in MM-FC dyads. The level of integration in MM-FC dyads is low and is mainly on the level 1, i.e. the transparency level. Exceptions are seen in the frequency of interaction and trust, which are the two areas that have reached the second level of integration.

Table 9. Present level of information integration in MM-FC dyads.

Element of integration	Level	Justification
Processes and activities		
Process coverage of information sharing	1	Information sharing does not cover all activities of the maintenance process. The execution activity is most integrated. Planning and control/feedback not adequately covered.
Degree of process integration	1	Focus is on internal activities. FC, for instance, has defined internal maintenance processes. For instance, planning carried out practically separately in FC and MM.
Information technology use		
Information systems coverage	1	Information is mainly shared informally. No information can be retrieved from FC's systems. Access to some information systems possible for service providers at FC's facilities. E-mail use is increasing.
Information systems integration	1	No integrated systems. No access to FC's systems provided for the service providers and vice versa.

Element of integration	Level	Justification
Information attributes		
Information form	1	Information is mainly shared informally or in paper-form. Form causes problems.
Information quality	1	In particular the accuracy and completeness of information could be improved.
Information availability	1	Availability is based on FC's willingness to share information and requires activity from the service provider. Thus, only some information is available exactly when and where needed.
Information sharing practices		
The coverage of information sharing practices	1	Practices are unstructured and concentrating mainly on sharing of operational information. Coverage of information sharing practices inadequate in the planning and control (feedback) activities.
The frequency of communication/ interaction	2	Relatively high frequency of interaction due to the close location, personal contacts, and need for retrieving tacit knowledge.
Collaborative foundation		
Shared goals	1	Operational goals seem to be dominating.
Shared resources	1	No actually shared resources or joint planning of the resources.
Trust	2	Moderate level of trust exists due to long co-operation and personal contacts. Problems are easily solved and not everything needs to be agreed in detail in advance.
Commitment	1	Low level of commitment, mainly because short-term contracts based on competitive bidding are used. Service providers are more willing to commit to longer-term co-operation than the FC.
Performance measurement	1	Mostly only internal performance measurement systems and measures. Quality system is used for service provider assessment.
Time-related issues		
Information lead-time	1	Lead-times can be prolonged due to low degree of IT use, high degree of informal information sharing and thus the importance of personal contacts.
Timing of information sharing	1	Several development areas in timing of information sharing were identified in MM-FC dyads.

4.4.2 Level of integration in EO-FC dyads

The main emphasis of information sharing in EO-FC dyads is on the planning phase i.e. before the annual overhaul (for EOs this includes the service definition and delivery). This is because naturally the planning work has to be completed and the planned parts or entities ready for installation before the annual overhaul begins. The most important information to be shared in EO-FC dyads is preliminary design data and specifications for the planning assignment, drawings, information about the components used/needed, and feedback. A more detailed description on the information flows in EO-FC dyads is presented in Appendix 4. Sometimes representatives from the EOs are also supervising the installation work of the planned entities during the annual overhaul. After the annual overhaul some changes and updates to the drawings may have to be done by the EOs based on the feedback from the FC.

Processes and activities

Engineering offices providing maintenance-related planning services receive orders through the FC's maintenance information system when planning work is needed, sometimes on a very tight schedule. When the annual overhaul is planned internally in the FC, there is, however, a person in the FC responsible for the contacts with EOs attending the meetings. EOs are involved in the FC's maintenance process often in earlier phase than the MMs. This is due to the nature of the planning services: they are more complex and need to be completed before the annual overhaul starts. EOs may be involved in the maintenance execution during the annual overhaul, if their employees are used in supervising the installation work of some planned entities in the FC. This is definitely a step towards integrating more the control and feedback activity in the service process. The reporting after the annual overhaul is done mostly internally in EOs and the FC separately. The FC gets some information (e.g. working time listings) from the EOs. However, the potential to collect and utilise data from supply chain partners still offers many untapped opportunities also in EO-FC dyads, especially in longer-term planning of the service operations and resource utilisation. This would particularly be beneficial, if there are changes in the personnel, as the new employees could then better utilise the earlier experience and knowledge in their work. Also the EOs consider the feedback link with the FC still weak. Particularly the lack of positive feedback is a deficit.

"No, probably we will not get any feedback (from the FC) if the planning work has succeeded. But of course then, if there are changes required". (The interviewee from EO1)

Information technology use

The EOs have access to the FC's maintenance information system and electronic drawings archive, which has been experienced very useful in the planning work. One of the EOs also has access to some parts of the FC's intranet. The EOs see the access to the FC's systems as an absolute necessity to be able to perform the planning work at all.

"The access to the FC's (maintenance) information system is a necessity for us. This type of work we are doing would become much more difficult, actually impossible, if we did not have the access." (The interviewee from EO1)

The access of the EOs to the systems could be, however, extended to cover more information, such as the failure and disturbance information and the repair history data for the production equipment. Access to inventory data regarding the parts utilised in the planned devices would also be beneficial to the EOs, so that delays in installing the planned entity caused by missing components or parts could be eliminated.

"I wonder if it would be possible to get access to the failure data and repair history data (at the FC)? I assume they have that kind of data (at the FC)….. That would be of help to us in the planning work." (The interviewee from EO2)

Some drawings are not yet in the electronic systems, but must be retrieved from the FC in paper form. Although the EOs can already retrieve much of the needed information from the FC's systems, some information still exists only in personal notes and files of the FC's personnel and not in the systems. Especially some of the information and knowledge needed in the service definition phase is difficult to put into systems. Replacing the old maintenance information system of the FC by a new one that will be easier to use and link with other systems and databases will provide more opportunities to increase the extent of electronically shared information in EO-FC dyads.

Information attributes

Information sharing in EO-FC dyads occurs to a larger extent electronically. Work orders and almost all drawings can be shared electronically. However, some documents (e.g. final drawings and working time listings) still have to be in paper form and require personal signatures. Information is also shared informally, especially when defining the extent and specifications for the planning work, as much of the information only exists as tacit knowledge among the FC's personnel.

> *"You can not write all the information down. It is a 'must' to go questioning around (in the FC)."* (The interviewee from EO2)

The quality of information in EO-FC dyads is generally perceived adequate and attributed to the use of information systems, but the diverse locations for information deteriorate the quality. Not all information is updated in the systems. For instance, sometimes the drawings retrieved from the archive are not up-to-date. Some documents might not be stored at all and some information only exists in employees' own notes. The EO-FC dyads would benefit from better version management of documents.

> *"There can be such problems, that there are old drawings that have not been removed (from the archive) and a new drawing has been made. And then we notice that and we need to check whether the things have actually been done as in the drawing."* (The interviewee from EO1)

Information availability is not seen as a problem if the information needed is in the systems, as in case of EO-FC dyads. However, as informal information sharing is still crucial in some stages of the planning services, difficulties in reaching the right persons and getting the preliminary design data needed may appear.

> *"Yes, I think we mainly get the information (from the FC) fast and easily enough. The only thing, especially occurring nowadays, is that there are difficulties to reach the persons needed as they are in such a rush….. Nowadays the information may be in possession of one person only." (*The interviewee from EO2)

The variation of presentation form of information may cause problems in informal information sharing also in some stages of the planning services.

Information sharing practices

The FC has dictated some procedures to be used with the EOs that are documented in a file in paper form. Moreover, some patterns for information sharing have been formed during long co-operation, but the EOs admit also that information sharing practices may vary depending on the persons involved.

> *"At one time the FC compiled design practice recommendations that has been delivered to us as a folder (in paper form) that contains the terms of reference."* (The interviewee from EO2)

> *"The discussions with the FC are, of course, in most occasions…..and probably all…somehow documented as notes or written into some kind of notebook."* (The interviewee from EO1)

The degree of informal information sharing is high especially in the service definition phase. EOs see informal discussions as an important part of information sharing with the FC. The tacit knowledge needed may be possessed by one single person at the FC.The large amount of tacit knowledge is thus a complicating factor also in EO-FC dyads and more effective ways to share and document it should be developed.

> *"The best way is usually to go face-to-face (with the FC's representatives) and then elaborate the drawing or the situation".* (The interviewee from EO1)

Unstructured procedures for information sharing restrict the quantity of informally shared information in EO-FC-dyads. More structured practices would be beneficial especially in the service definition phase and in the feedback phase.

The frequency of interaction in EO-FC dyads is quite high due to close location, personal contacts and the need for retrieving tacit knowledge from the FC's personnel. Also the access to the FC's information systems increases the frequency of communication. EOs' personnel visit the FC's facilities quite often and can also move quite freely at the FC's facilities, which facilitates the informal information sharing.

Collaborative foundation

The EOs are situated close to the FC and have a long history of co-operation with it. In discussions with the engineering offices, it was clearly stated that the FC is

their key customer, with longer-term (one year) contracts and a certain number of resources reserved for the FC's use.

Based on the interviews, the level of trust in the EO-FC dyads can be described as moderate. Companies have worked together for decades; employees know each other personally and feel that problems or sudden changes can be easily managed. Not all pertinent information and information systems, however, are shared with the EOs. Access to the FC's information systems, longer-term contracts, and resource capacity reservation are, then again, a sign of moderate mutual commitment in EO-FC dyads.

> *"We know each other well. That derives from the long history of co-operation."* (The interviewee from EO2)

> *"Let's say that it is a common interest to solve the problem and change situations with the FC. There have not actually been situations in which the shift would be blamed onto the other party."* (The interviewee from EO1)

The common goals in EO-FC dyads seem to be mainly at operational level. The main target is to complete the agreed planning assignment in time. There is no common performance measurement system between the EOs and the FC and very little performance data is shared. The EOs have their own information systems or files for reporting, for instance costs and person-hours of the planning tasks. Possibilities for the EOs to give feedback to the FC are limited and feedback is mainly given informally.

The resource capacity reserved by the FC helps to allocate the resources more effectively. Using EOs' representatives in supervising the installation of the planned devices is also a sign of moving towards resource sharing in the future.

Time-related issues

Information lead-time in EO-FC dyads is perceived acceptable, above all, if the information is retrieved from systems. Also in case of informal information sharing all necessary information can eventually be received if knowing from whom to ask or where to look for. However, this often necessitates reaching certain persons, and thus the lead-time for information sharing can be sometimes prolonged.

Timing of information sharing is in general perceived acceptable in EO-FC dyads, as much of the information can be retrieved from information systems. A

few flaws in the timing and lead-time of information sharing were recognised. They are mostly related to some information shared in paper form that could be quite easily shared in electronic form and thus faster.

> *"You need to find the right person to get the signature (for the working time listings). If you could send it electronically to be signed then you would not need to do that. It would save time. That is one thing at least."* (The interviewee from EO2)

> *"It is of course a question, from where in the archive to find the information, if there are that type of drawings, which are not in electronic form…. Then we need to use the FC's personnel to find them…Thus, finding these drawings may be quite a laborious task."* (The interviewee from EO1)

Summary on integration levels

Table 10 presents a summary on the levels of information integration along the six integration elements in EO-FC dyads. A medium level of integration in the EO-FC dyads was observed, as the level of integration reaches the integration level 2 (commitment/coordination) along most of the integration elements. Exceptions are found in processes and activities, in some areas of collaborative foundation, and in the coverage of information sharing practices, where the level of integration remains lower.

Table 10. Present level of information integration in EO-FC dyads.

Element of integration	Level	Justification
Processes and activities		
Process coverage of information sharing	1	Information sharing does not cover all activities of the maintenance process. Planning and control/feedback not adequately covered.
Degree of process integration	1	Focus is on internal activities. Planning still carried out practically separately in FC and EOs. Using EOs in installing the planned entities facilitates integration in feedback/control phase.
Information technology use		
Information systems coverage	2	EOs have access to majority of the pertinent information through FC's information systems. Not all necessary information is in the systems or accessible for the EOs.
Information systems integration	2	Access to some crucial maintenance-related information systems/archives in FC is provided to EOs. Some information is still dispersed in other separate information systems which EOs can not access.
Information attributes		
Information form	2	Much of the information in systems. Information shared informally in service definition phase. Form causes sometimes problems.
Information quality	2	If information is in systems, the quality is acceptable. Some flaws, e.g. technical changes not always updated in drawings.
Information availability	2	Information accessible in systems is available when needed. In informal information sharing availability is based on FC's willingness to share information and requires activity from the service provider.

Element of integration	Level	Justification
Information sharing practices		
The coverage of information sharing practices	1	Some practices dictated by the FC and concentrating mainly on sharing of operational information. Coverage of information sharing practices inadequate in the planning (service definition) and control (feedback) activities.
The frequency of communication/interaction	2	Relatively high frequency of interaction due to the close location, personal contacts, need for retrieving tacit knowledge, and the links to information systems.
Collaborative foundation		
Shared goals	1	Operational goals seem to be dominating. Most important goal is to complete the planning work.
Shared resources	1	No resource pooling or joint planning of the resources. Resource capacity reserved by FC and use of EO staff in supervising the installation of some planned entities are an indication of moving towards level 2.
Trust	2	Moderate level of trust exists due to long co-operation and personal contacts. Problems are easily solved and not everything needs to be agreed in detail in advance.
Commitment	2	Medium level of commitment, because of longer-term contracts, reserved resource capacity, and access provided to the information systems.
Performance measurement	1	Mostly only internal performance measurement systems and measures. Very little performance data shared.
Time-related issues		
Information lead-time	2	Information shared through systems to a great extent, which cuts the lead-time. Informal information sharing and personal contacts still crucial in some stages.
Timing of information sharing	2	Timing is acceptable. Problems in timing only in informal information sharing due to person dependency.

4.5 Context and levels as the foundation for developing integration

4.5.1 Levels of integration in theory and practice

The current level of information integration in case supply chain dyads now has to be compared with the level suggested by the contextual setting. The differences between MM-FC and EO-FC dyads are discussed to see if they can be explained by the contextual setting. The levels of information integration in the case supply chain dyads are summarised in Table 11 to enable the comparison.

Table 11. Summary on the levels of information integration in case supply chain dyads.

Element of integration	Level in MM-FC-dyads	Level in EO-FC dyads
Processes and activities	1	1
Information technology use	1	2
Information attributes	1	2
Information sharing practices	1–2	1–2
Collaborative foundation	1–2	1–2
Time-related issues	1	2
Aggregate level of integration	1	2

When comparing the actual level of integration in the case supply chain dyads to the levels proposed by the contextual setting, it can be noted, that the empirical research results concerning the level of integration support the proposed theoretical model on contextual factors. The four MM-FC dyads have a low level of integration (level 1), which corresponds to the level of integration suggested by the theoretical model, as in these dyads, the resources are somewhat shared, service complexity is low, customer relationship between loose and moderate, cost is the order winner, level of interdependence is medium, and uncertainty in service volume is moderate. The two EO-FC dyads are characterised by fairly buyer-focused resources, relatively high service complexity, loose to moderate customer relationship, quality and flexibility as the main order winners, medium level of interdependence, and medium uncertainty in service volume. The EO-FC dyads have achieved a medium level of integration (level 2), as also suggested by the theoretical propositions.

It seems reasonable that the FC can and should develop a higher level of integration with the EOs than the MMs. This is due to the higher degree of service complexity, greater interdependency, and higher importance of flexibility as the order winner in EO-FC dyads. Considering the current contextual setting in the

case supply chain and the role of maintenance process as a support process to the production process, there seems to be no need to develop the information integration in the maintenance service supply chain dyads to level 3. Instead, developing the integration within the current levels in the dyads is suggested. However, there has been discussion on moving to longer-term contracts with at least some of the MMs. If this plan is realised, moving to integration level 2 with these service providers is necessary.

In MM-FC dyads the elements with most important development needs are the information technology use and information attributes which also reinforce each other. Developing these will also affect the time-related issues in information sharing. If, as it seems, a move towards longer-term contracts and closer cooperation is made, the areas of collaborative foundation and processes and activities should also be developed further. Especially the feedback activity in the maintenance process was experienced problematic. The MMs perceived that they did not receive enough feedback concerning their service performance. Also involving the MMs to the maintenance process already in the planning phase could facilitate integration and its performance effects due to more efficient resource planning and utilisation, and the elimination of overlapping planning activities.

In EO-FC dyads the collaborative foundation could be further deepened, especially regarding the shared goals and developing joint performance measurement. In resource sharing the development is already going to a more integrated direction. Access to FC's information systems has been perceived especially beneficial in EOs and thus the information systems coverage could be further extended. A variety of information that could be beneficial if shared with EOs, came up in the interviews. Moreover, the element of processes and activities is at level 1 although the medium level of integration would propose a higher level. This is due to the inadequate integration in the maintenance planning activity. The EOs are typically included in the FC's planning activity relatively late. Earlier involvement would contribute to trusting relationships and thus tacit knowledge transfer between companies. This has been earlier emphasised in the context of product development process e.g. by Foos *et al.* (2006).

It is interesting to see that the notion of trust in the collaborative foundation in MM-FC dyads has developed to level 2, although integration in general is on level 1. This may be explained by the fact that the uncertain nature of services makes it more difficult to design and implement operational processes at the service provider-customer interface and hence increases the importance of the

partnering aspects in the relationship (see Field & Meile 2008). Another exception in MM-FC dyads seems to be the frequency of interaction/communication settling on level 2. This might derive from the complex and dynamic nature of the service process, which necessitates communication with the customer and problem solving during the process. Even when the mechanical maintenance services are routine-type, the delivery process involves unexpected changes.

Interestingly, the trust in MM-FC and EO-FC dyads seems to have been established through frequent on-site interactions between the employees and seems to be a personal level trust. This kind of trust may have some limitations, as, for instance, high turnover of employees may lead to loss of trust (see Sheu *et al.* 2006). High level of trust, in general is a positive sign. For instance, Monczka *et al.* (1998) have stated that trust is a more important factor in determining relationship success than the formal commitments of time and money. The trust provides a basis for the dyadic relationships with the service providers to be developed to a higher level of integration, if needed.

Neither of the two types of dyads had developed common performance measures. This is especially surprising for the EO-FC dyads, as integration level in them is otherwise medium. However, other similar indications exist in the literature. For instance, Forslund & Jonsson (2007) introduce a study on integrating performance management in delivery services. They found out that the level of integration in performance management was generally lower than the level of integration in overall business processes, despite the fact that the dyadic relationships studied were characterised by both trust and collaborative culture.

4.5.2 Development areas in the case supply chain information sharing

During the second workshop and the structured interviews, a myriad of development areas in the case supply chain information sharing were identified. These problem areas were later prioritised in the fifth workshop and in the end screened out to six major development areas. The root causes for the problems were analysed based on five given categories: information users (the people mediating, processing or utilising the information), information systems (technology, systems, and databases in information sharing), procedures for sharing and utilising information (the existence of practices for sharing and utilising information and following the practices), the maintenance process (the work environment, the characteristics of the maintenance process), and other

reasons causing the problems. The six major development areas and their root causes are presented in Table 12.

Table 12. Main development areas in the case supply chain information sharing.

	Development area	Root causes of the problem
1	Information is dispersed in different information systems and sources	information system maintenance process
2	Information does not flow fast enough and there are problems in timing of information sharing	information users information system procedures for information sharing and utilisation maintenance process
3	Information does not always reach all the recipients that it should	information users information system procedures for information sharing and utilisation
4	Information is not sufficiently documented/updated	information users procedures for information sharing and utilisation
5	Information shared is often incomplete, not updated, or presented in a form that is clear enough for the users of information	information users information system procedures for information sharing and utilisation OTHER: rush and resource restrictions (related to the process)
6	Information gathered/received is not utilised comprehensively	information users procedures for information sharing and utilisation OTHER: short-term collaboration

Procedures for information sharing and utilisation (or rather deficits and inconsistencies in them) are the prime cause for the problems related to information sharing, but information users are considered almost equally important. Third major factor causing the problems is formed by the information systems. However, their role is also seen as a potential solution for reducing the problems caused by the procedures and users. That is, because developing the information systems and increasing their use would reduce the person dependence and possibility for human mistakes in information sharing, and thus diminish the negative effects of users and procedures. The maintenance process is considered

to be complex, dynamic and hectic, but its meaning in creating the problems is seen rather insignificant. The other reasons that were identified can be associated with the nature of the maintenance process. One distinct factor, which is not describing the process characteristics, however, was the short-term contract focus with mechanical maintenance service providers, which is considered to affect the information sharing negatively.

Generally, the large amount of tacit knowledge and informal information sharing complicate the information integration in the case supply chain. Valuable tacit knowledge may also be easily lost as aging employees retire or employees change jobs and if existing service providers are replaced by new ones.

Similar problems in information sharing have been found in other studies. In a case study on an industrial service organisation (Minkus & Nobs 2006), it was found out that no rules for information exchange existed, a variety of non-integrated IT solutions existed, the IT solutions were inadequate in handling and their functionality, the exchanged documents had a low grade of quality, and service employees had started making their own notes and sharing them with only the people they knew. Minkus *et al.* (2007a) add, that lack of coordination between different elements of a service organisation leads to additional expenses and increases the time needed for information exchange. Independently developed local IT solutions and inadequate consideration of the process which the IT was supposed to support led to a situation where searching for information was complex and time consuming. (Minkus *et al.* 2007a).

Similar problem areas have been identified by Piispa (2007). She states that delays, additional work, and repeated actions occur in maintenance, because information can not be found fast and easily from the manual or electronic systems and the information needed is poorly or insufficiently maintained. Piispa (2007) also points out that lack of common procedures in the process and a comprehensive approach to develop the maintenance service process as one entity lead to a situation, where people start creating their own various procedures for doing things. This leads to ambiguity and incoherence in maintenance process and causes delays, and can ultimately affect negatively the maintenance quality and the reliability of operation.

5 Facilitating information integration in steel industry maintenance service supply chain

This chapter elaborates the means to develop information integration in the case supply chain and the potential supply chain performance effects to be pursued through the development (RQ3B).

5.1 Maintenance service supply chain performance goals

In the structured interviews, the case supply chain informants identified the following effects that developing the information sharing in the case supply chain would have on the supply chain performance:

- Eliminating unnecessary activities in the process,
- improving service quality,
- time savings,
- cost savings,
- making the planning work more effective,
- deepening and intensifying the collaboration of supply chain companies, and
- gaining a better understanding on the customer's (focal company) needs and better response to them.

In the workshops, the company representatives distinguished developing the quality of maintenance-related planning services, developing the quality of mechanical maintenance services, increasing the transparency of maintenance supply chain, and deepening the collaboration in the supply chain as the most important performance goals. Reducing the total maintenance costs, elimination of non-value-adding activities, and improved resource utilisation were considered fairly important objectives for the maintenance supply chain.

Generally, the performance goals in case supply chain can be consolidated in three main goals:

- Developing the service quality,
- deepening the supply chain collaboration, and
- streamlining the maintenance and maintenance service processes (operational efficiency).

The goals are related to all four performance aspects in supply chain (cost, time, quality, and flexibility). The efficiency improvements through streamlining the

supply chain processes and thus cost reduction, and shortened service delivery lead times (or other type of time compression) have been demonstrated to be important consequences of supply chain collaboration by Min *et al.* (2005). Two other factors identified in Min *et al.* (2005) research, namely mutuality and reinforcement and expansion of the relationship, are also reflected in the case supply chain's goal of deepening supply chain collaboration. Closer collaboration could enable service providers to offer more comprehensive services to the FC and the service providers' competence could be better utilised.

When considering, whether the performance objectives can be positioned on operational or strategic level, classification used by Mukhopadhyay & Kekre (2002), Subramani (2004) and Sanders (2008) can be applied. Operational benefits rise directly from lowered transaction and production costs. Strategic benefits, then again, arise through firms positioning themselves to take advantage of opportunities arising from the supply chain relationship. In service supply chain this could mean development of a new service or the ability to respond to challenges in the supply chain relationship. The goals in case supply chain mainly reflect operational level objectives related to cost and time savings. However, developing the collaborative foundation refers to the need to better understand customer's needs and thus identifying new service opportunities and new modes of operation.

Unless the organisation can define, track and measure the critical outcomes signifying the achievement of its supply chain goals, it can not determine the effectiveness of its supply chain practices or carry out any imperative adjustments in them (see e.g. Brewer & Speh 2000, Lee & Billington 1992). Thus, one important development step in the case supply chain is introduction of joint performance measures. This is especially important for the EO-FC dyads, which have a higher level of integration. Table 13 presents the aspects of supply chain performance (cost, time quality, and flexibility) and gives examples of the operationalisation of these aspects as potential performance measures to be used in the case supply chain.

Table 13. Measuring the supply chain performance aspects in the case supply chain.

Aspect of supply chain performance	Potential measures in the case supply chain
Cost	Total maintenance cost
	Service cost
	Resource cost (human resources, materials, etc.)
	Resource utilisation
Time	Service delivery cycle/lead-time
	On-time deliveries of services
	Adherence to schedules (lateness/earliness) in maintenance services/activities
Quality/reliability	Quality of delivered service: Customer expectations vs. perceptions on service quality
	Number of complaints regarding the delivered services
Flexibility	Service volume flexibility
	Responsiveness to urgent service deliveries
	Flexibility to meet particular customer needs
	Resource flexibility
	Number of tasks a worker can perform

The maintenance cost in the case supply chain should be measured in more detailed level. The new maintenance information system in the FC will provide better opportunities for gathering more accurate cost data. Costs related to the external maintenance services could be jointly measured with the service providers and thus factors causing increases in cost identified.

Measuring the adherence (compliance) to schedules in maintenance services/activities would help in assessing the effectiveness of the scheduling techniques in use and identifying potential development areas in maintenance planning and scheduling. The measure would provide information on realised vs. planned schedules which could be utilised in planning of the next annual overhaul shutdown and other maintenance activities. More information would also be gained regarding the time needed for performing a certain service.

Through measuring the service delivery cycle, the reliability and consistency of service lead-time could be assessed and potential actions taken to develop it. In engineering offices measuring the lead-time is outstandingly difficult, as the variety among the service entities provided by the EOs is high. However, indicative data on the lead-time could be acquired also in the EOs by paying

attention to factors affecting the lead-time such as the number of changes or other complicating factors in the engineering projects. Also in mechanical maintenance it is difficult to define a certain standard time for repairing some of the more challenging failures. Thus, attention should be paid to disturbances causing delays in the process, and not solely the lead-time (see also Piispa 2007).

Quality was among the case supply chain performance goals and necessitates a more systematic measuring approach regarding the service quality. Earlier contributions in service quality (e.g. SERVQUAL by Parasuraman *et al.* (1988, 1994) could be utilised to develop the quality measure so that the service aspect is emphasised more.

Flexibility describes the efficiency with which the maintenance (service) processes can be changed. It could be measured in the service processes through the aspects of flexibility in service volume, service mix, and resource mix. These measures, however, are more strategic or tactical level measures and may not be considered important yet in dyads with low level of integration. Flexibility concerning the human resources at operational level could be measured, for instance, through number of tasks a worker can perform. This kind of data enables better allocation of resources, as the competence of employees is better known.

The performance measures suggested in the framework are based largely on metrics discussed in the literature (e.g. Gunasekaran *et al.* 2004, Gunasekaran *et al.* 2001, Shepherd & Günter 2006). The case supply chain has undoubtedly its unique performance needs and the framework should be adjusted to them. The appropriateness of various performance measures in a dyad depends on the service provider and focal company characteristics and different measures may thus be emphasised in different types of dyads. Moreover, before adopting the common performance measures in the case supply chain, they should be evaluated in terms of the cost of measuring compared to the benefits the measurement brings. Thus, the suggestions in Table 13 should be seen more as a starting point for developing measures for supply chain performance in the maintenance service supply chain dyads. (see also Gunasekaran *et al.* 2004, Shepherd & Günter 2006). Shepherd & Günter (2006) further point out, that measurement systems should be treated as dynamic entities that must respond to environmental and strategic changes. Connected with the information integration focus of this study, this means that the measurement system should be adjusted to the level of integration emphasising more operational measures when the

integration level is low, and relying more on strategic level measures when the integration level is high.

5.2 Guidelines for more structured information integration

More attention should be paid to developing information and knowledge sharing in service supply chains as information is critical in offering, delivering and evaluating services. This study suggests six aspects to be considered when examining information integration in service supply chain: processes and activities, information attributes, information technology use, information sharing practices, collaborative foundation, and time-related issues. This study shows that analysing the level of information integration in supply chain dyads is a useful tool for identifying development areas and adopting a more holistic and structured approach for information sharing. A more structured approach to information sharing will make it easier for the case supply chain to control, manage and further develop the dynamic information sharing process related to service operations.

It is typically the focal company that makes decisions regarding the integrative approaches or practices taken (see also Spens 2001). In the case supply chain, the focal company as a large and powerful actor should assume the 'information leadership' to achieve the developments needed. This is especially important, because the service provider companies are SMEs with scarce resources.

Three main action points for developing information integration in the case supply chain are recommended:

- A centralised maintenance information system,
- common procedures for sharing and utilising information, and
- commitment of supply chain actors.

Similar recommendations have been presented in earlier research. For instance, Detlor *et al.* (2006) emphasise the need for establishing formal policies and procedures and implementing requisite technology infrastructures to promote knowledge sharing among organisation's employees.

All maintenance-related information should be available through one single *centralised maintenance information system*. The service providers should also have at least a limited access to the system. The centralised information system should provide, for instance, the access to historical maintenance data through

one single point, the possibility of creating concise summary reports and graphical presentation of information, which was experienced important among the case supply chain companies.

The focal company as a powerful partner has a central role in providing the shared information system. Making this kind of idiosyncratic (i.e. relationship-specific) investments are associated with the investing partner's stronger commitment to the relationship and higher integration of business activities and leads to the other partners' stronger commitment to the relationship (Wu *et al.* 2004). Regarding the information system, a challenge facing the focal company is to balance the security and privacy requirements with the needs of information availability and access for the service providers (see e.g. Kumar & Thondikulam 2006). It should also be made possible to flexibly and rapidly expand or narrow the access of external users to the information in the systems, depending on the roles and responsibilities in the maintenance activities. There is a challenge of getting all maintenance-related information into one system from separate systems and archives. The information from current maintenance information system and databases should be transferred to the new system or links between the new and old systems constructed. One alternative that was also piloted in the SEBI research project is to use semantic technologies in ensuring the interoperability links between the different databases and systems (see e.g. Uusipaavalniemi *et al.* 2009).

Through the centralised information system, the extent of information shared with the service providers could be relatively easily increased. Expanding the extent (quantity) of shared information naturally increases the possibilities of joint planning of the maintenance activities in the case supply chain. Some examples of information that can quite easily be shared in electronic form are maintenance schedules, information on employee qualifications, resource listings, working time listings, and memos of the meetings. The system will help in achieving more rigorous documentation and storage of the maintenance information to improve its usefulness in planning and decision-making.

Russell & Hoag (2004) have noted that the most significant challenges in implementing IT are not technical in nature, but rather human. Thus it should be ensured, that the users of IT perceive it beneficial and easy to use. Personalised user interfaces could be used to eliminate the negative effect of information overload on employees. Technologies, such as mobile technologies, RFID (Radio Frequency Identification), and speech recording, could be deployed in ensuring

the user-friendliness and quick and effortless data input during the hectic and dynamic maintenance work.

Common procedures for sharing and utilising information in the case supply chain should be formed. To ensure adequate information links between the focal company maintenance process and maintenance service processes, the processes should be defined and unnecessary and overlapping links eliminated. The procedures should be delimited to a better manageable set. The form, location and sharing procedure of information should be aligned. As thus a more standardised set of procedures can be formed and documented, it will also be easier to develop the procedures in the future.

Some of the already existing information sharing procedures could be better utilised in information and knowledge sharing. For instance, the yearly 'closing session of the annual overhaul' could be better utilised as a joint workshop between the focal company and service providers in order to facilitate problem solving and development of the maintenance process and related practices. Joint problem solving can, at its best, lead to mutually developed process improvement ideas. It can be accomplished through formation of cross-organisational teams or co-locating each other's personnel. (Min *et al.* 2005). Perhaps even new service solutions could be eventually established based on this kind of feedback.

The direct contacts between supply chain parties have been shown to be important, even more important than IT (e.g. Welker *et al.* 2008). Thus, IT should not, and in service operations even can not, fully replace the informal communication channels. Moreover, for instance the timing of information sharing depends on the social and individual activities in organisation (Widén-Wulff & Davenport 2005). Thus, practices for informal information sharing and especially sharing the tacit knowledge, should be developed. Practices that could facilitate tacit knowledge sharing include the use of cross-organisational teams, co-location of employees, and master-apprentice system that could be functioning between the focal company and service providers. Moreover, social interaction between the FC's and service providers' employees in general should be ensured both through informal and formal links. The organisation to cross-functional teams does not have to be formal. For instance, Bhatt (2002) highlight the self-organised teams and group social interaction in facilitating knowledge management.

The third step is creating the *commitment of supply chain actors.* The focal company and service providers should be committed to follow the agreed practices and use the shared information system. This commitment can be

initialised by involving the service providers in creating and developing the joint practices for information sharing.

Joint performance evaluation and providing better feedback to service providers would facilitate the development of service providers in terms of service provider performance and capability improvements. Communicating the feedback on performance is essential in creating commitment and facilitating collaboration. Developments in the collaborative foundation have a self-reinforcing effect. For instance, the collective information obtained through joint performance measurement can be used to further expand the collaboration in scope and boundary (Min *et al.* 2005).

Moving to longer-term contracts with the mechanical maintenance service providers would enhance the commitment of the service providers to the relationship and integration. Integration has often been facilitated through reduction in the number of organisations in the supply chain, so moving to longer-term contracts might mean also cutting the present number of mechanical maintenance service providers. Longer-term contracts are likely to increase the service providers' own motivation to develop the service processes and working methods and can thus improve the service quality and facilitate service innovation. The challenge for the focal company is how to retain a certain degree of flexibility to enable responding to the changes in business environment, while yet moving to longer-term contracts with the service providers.

Rewards or sanctions could be used to change the behaviour of the employees and to facilitate the adoption of and commitment to joint procedures and the new information system in information sharing. Suitable reward and compensation structures should be developed together with the service providers.

According to Sheu *et al.* (2006), the appropriate use of IT to improve external integration in supply chain requires also willingness to use IT, which is not necessarily always present. In the case supply chain, the willingness could be established through providing adequate training and instructions related to the new information system.

The three development lines introduced (centralised information system, common procedures, and commitment) bring more structure to the information sharing in case supply chain. Min *et al.* (2005) view this kind of *formalisation* as an antecedent of collaboration, including joint performance metrics, defining common goals and objectives, clarifying the roles, responsibilities, and reporting mechanisms, moving to collaborative planning and scheduling, use of

collaborative (standardised) technology and specifying the information to be shared.

Finally, integration in supply chain is an on-going process and thus the progress of efforts directed towards enhancing integration should be monitored against predetermined targets (e.g. Christopher & Juttner 2000). Continuous assessment and development of information integration in the case supply chain is important, as changes in the business environment may also affect the needs and requirements for information sharing. Attention should be paid to communicating performance feedback in the supply chain (dyads) as it is a prerequisite for taking the corrective actions needed. A recapitulation of the development guidelines regarding information integration in the case supply chain is presented in Figure 15. The four elements in Figure 15 (people, structure, technology, and maintenance processes) are based on Leavitt's (Leavitt 1965) model of organisational change involving people, structure, technology, and tasks.

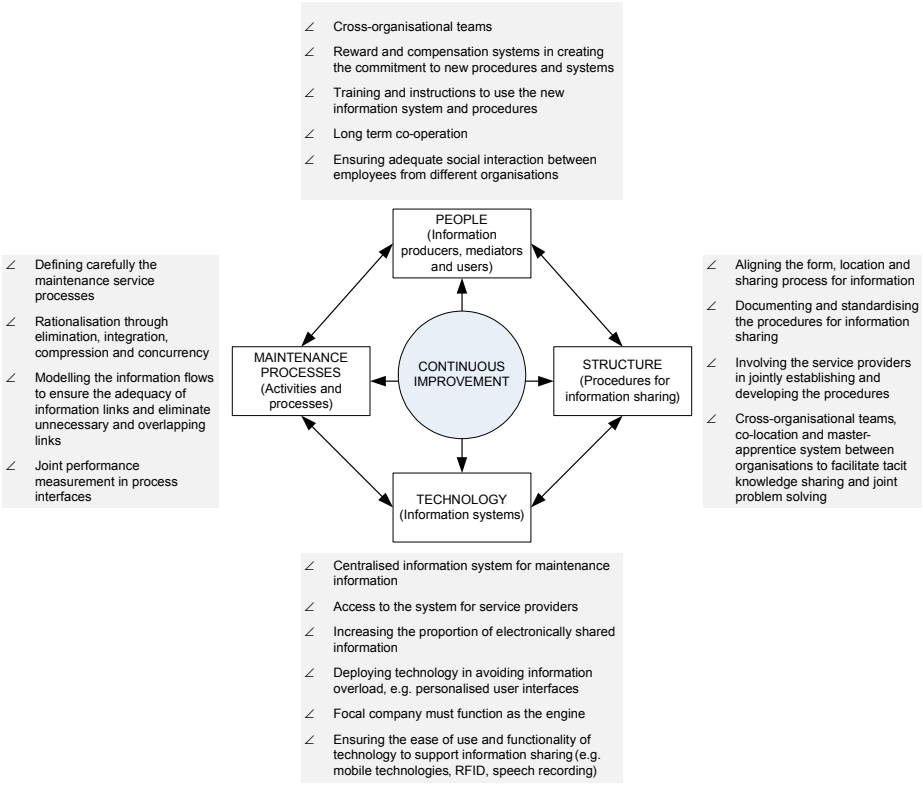

Fig. 15. Facilitating information integration in the case supply chain.

6 Discussion

6.1 Contribution of the study

SCM is both an emerging field of practice and an emerging academic discipline, each of which is facilitated by and dependent on the other (Storey *et al.* 2006). The abductive research approach used in this study acts as a link between theory and practice and helps in addressing problems deriving from the interplay and misalignment between them.

This research was carried out to understand, explain and describe information integration in service supply chain context. It will act as a basis for the discussion on the appropriate extent of integration in service supply chains derived from the prevailing contextual setting and performance objectives of the chains. Next, answers to the research questions of this study are shortly presented.

RQ1: Elements of information integration

Information flow emerges as a key construct in service supply chains and should be managed efficiently. Information is vital in managing the complexity and uncertainty embedded in service supply chains due to the special characteristics of services; intangibility, inseparability, heterogeneity, perishability, and labour intensity. Information integration in service supply chain is also closely tied to the performance benefits it can create.

Information integration is a complex and multifaceted concept and analysing and developing it necessitates considering several different elements. Six elements of information integration in service supply chain are identified: processes and activities, information attributes, information technology use, information sharing practices, collaborative foundation, and time-related issues.

All six elements were found vital in the case supply chain. However, they have differing roles. Information attributes and time-related issues are considered in defining the objectives or orientation for information sharing. Information technology use and information sharing practices are seen as main tools to achieve these objectives. Finally, collaborative foundation and processes and activities form the support structures for information sharing.

RQ2: Contextual setting and extent of integration

The extent of integration in a supply chain can be defined through levels of integration. In this study, a classification involving three levels of information integration is used. The levels are transparency, (level 1, the lowest level) commitment and coordination (level 2), and integrative planning (level 3, the highest level). Level 1 involves sharing of some pertinent data, but independent decision-making in supply chain companies in a dyad. At level 2, most of the relevant information is shared and mutual commitment in supply chain dyad exists. Level 3 involves joint planning and coordination as integration is taken into a more strategic level. As the level of integration rises, the extent of information and its strategic importance increases as well. The levels are suggested to be defined along all six information integration elements to ensure the comprehensiveness of the analysis.

Six variables affecting the level of information integration in a service supply chain are identified: type of resources, degree of complexity of the services (i.e. uncertainty in service mix/specification), closeness of the customer-service provider relationship, order winners, interdependency, and uncertainty in service volume. Service supply chain dyads with shared resources, routine type of services, loose customer-service provider relationship, cost as the order winner, low level of interdependence, and low service volume uncertainty are proposed to have a low level of integration (level 1). On the contrary, service supply chain dyads with high buyer focus, customised services, close customer-service provider relationship, flexibility and/or quality as the order winner(s), high level of interdependence and high uncertainty in service volume are assumed to have a high level of integration (level 3). In between settles the level 2 integration.

Different levels of integration were observed in the two different types of case supply chain dyads. MM-FC dyads all demonstrated a low level (level 1) of integration. EO-FC dyads were classified as having a medium level (level 2) of integration. The empirical case study also supports the proposed theoretical model on the effect of the context on the level of integration. The low level of integration in MM-FC dyads corresponds to the level suggested by the theoretical model, as in these dyads, the resources are somewhat shared, service complexity is low, customer relationship between loose and moderate, cost is the order winner, interdependence is moderate, and uncertainty in service volume is medium. The EO-FC dyads are characterised by fairly buyer-focused resources, relatively high service complexity, loose to moderate customer relationship,

quality and flexibility as the main order winners, medium interdependence, and medium uncertainty in service volume. These dyads had achieved a medium level of integration (level 2), as was also proposed by the status of contextual factors.

RQ3: Facilitating information integration and supply chain performance

Information integration affects the time, cost, quality, and flexibility performance in a supply chain. Improved performance can be realised by developing the six elements of integration. As the level of integration increases from low to high integration, the emphasis on performance management extends from operational to strategic level and longer-term benefits are sought.

The performance objectives in the case supply chain are related to developing the service quality, deepening the supply chain collaboration, and gaining operational efficiency through streamlining the maintenance and maintenance service processes. Three major action points were identified to develop information integration in the case supply chain: a shared, centralised maintenance information system, common procedures for sharing and utilising information, and commitment of all supply chain actors to use the system and follow the agreed procedures.

To conclude, analysing the level of information integration in supply chain dyads is a useful tool for identifying development areas and adopting a more holistic and structured approach for information sharing. A more structured approach to information sharing involving commonly agreed procedures and systems and commitment to utilise them will make it easier for the supply chain to control, manage and further develop the dynamic information sharing process related to service processes.

6.2 Implications

6.2.1 Theoretical implications

The most important theoretical contribution of this study is the conceptual framework for information integration. It addresses the need for more holistic and interdisciplinary frameworks to describe supply chain integration and information sharing. The complex phenomenon of information integration has been simplified in the framework, but yet viewed from multiple perspectives. The framework

offers rough guidelines for assessing and measuring the level of integration, which has been experienced challenging in the integration research so far. The framework also addresses the research gap of theoretical guidelines for decision making in implementing and developing integration in supply chain relationships. The initial operationalisation of the elements that was used in this study could, in the future, be developed further and adjusted to other types of case environments.

As Ellram *et al.* (2004) state, whether it is about services or manufacturing, underlying issues are the same: how to design and manage a supply chain, control the assets and uncertainties to best meet the customer needs in a cost-effective manner. However, the special characteristics of service context *can* and *should* be utilised in designing and managing the service supply chain; for instance, as this study demonstrates, in choices and developments regarding information integration.

The service focus of the case contributes to the so far limited research on business services and information sharing related to service supply chains. The maintenance service supply chain study presented in this thesis justifies the need for information integration in business services. It shows the information integration levels and development needs on a certain service segment serving certain type of industry, which is needed as the research related to services so far has been at a very general level.

In earlier SCI research the emphasis has been on differentiating integration *between* supply chains. For instance, Bagchi & Skjoett-Larsen (2002) have identified the need for selective integration in supply chains. This study, however, proposes that differentiating the levels of integration *within* supply chains might be beneficial as well. A recent study by Harland *et al.* (2007) has also suggested the need for differentiation in integration within supply chains. This premise certainly needs to be further considered in forthcoming research.

This study further supports the idea that information and knowledge sharing occurs through the reciprocal relationships among the supply chain partners (see e.g. Kumar & Thondikulam 2006). Thus no company can achieve the integration and its performance benefits independently, but through joint, inter-firm efforts. Service providers should be included in the integrative actions just like any other members of the supply chain. What is more, service providers can and should contribute to integration and thus supply chain performance (see also Fabbe-Costes *et al.* 2009).

To conclude, this study helps to better understand the concept of integration and its various dimensions and implications, which is of both managerial and

academic importance (e.g. Fabbe-Costes & Jahre 2008) and can further contribute to theory building in domains of SCM, operations management, and services management. Clarifying the concepts will make it easier to identify differences and similarities respect to prior research and contribution to the current theory development, which has, according to Fabbe-Costes & Jahre (2008) been experienced as a problem so far.

6.2.2 Managerial implications

This study has a number of practical implications for the case companies involved in it. By roughly determining the current level of integration the development areas in the information sharing in the case supply chain were clearly identified and thus key areas for improvement provided. The conceptual integration framework enables a more holistic view of information integration in service supply chains, but on the other hand makes it possible to decompose information integration into separate elements. The level of integration can then be analysed for each element to better identify the elements with most urgent development needs. The framework illustrates well the multi-dimensionality of information integration and the inter-relatedness of the dimensions. It helps companies to understand that they need to deal with partners with varying levels of collaborative foundation and that, for instance, the supply chain relationship issues affect the possibilities to utilise IT capabilities and achieve an appropriate extent of information sharing in a relationship. High level of information integration requires significant efforts and resources and is not always appropriate in a service supply chain dyad. Perhaps an approach with 'portfolio' of relationships with different levels of integration would be suitable to be applied to the service provider base in the future. Organising the service provider base according to a certain portfolio and managing the service providers as an extension to the focal company's maintenance system/process could be used as a tool to seek performance improvements.

Understanding the effect of the context on the level of integration helps the companies in setting the practical ways to achieve integration as the barriers and drivers for integration are thus better identified. Companies can choose the intended level of integration in a dyad based on the desired performance effects and then, strive towards the target level by actively changing the status of the contextual factors and developing the six integration elements accordingly.

Providing the description of information sharing and identifying the development areas related to it was perceived useful in the case supply chain companies. The problem areas related to information sharing identified in this study are also relevant to be considered in other service supply chains. The key for managers is to understand that information integration with service providers is crucial and paying attention to information flow in service operations can be beneficial to supply chain performance. Another key issue is that different levels of integration with different kinds of service providers are attainable and this kind of differentiated approach to integration is recommended based on this study. The conceptual framework presented in the study helps in gaining a holistic view of information integration in a service supply chain and thus better recognising the opportunities for developing distinguished integration levels. In addition, the results may offer a basis for developing contractual mechanisms, such as service level agreements, typically found in IT outsourcing arrangements (see e.g. Larson 1998) but still under-utilised in many other service industry contexts. Similarly, the performance-based partnering concept (e.g. Straub 2007) could be further elaborated by integrating the elements of information sharing into the performance requirements in a service supply chain.

Services have some special features, due which service deliveries can not be managed similarly to material deliveries. These unique characteristics of services should be kept in mind when selecting the practices and technologies for facilitating information sharing in a service supply chain. Semantic technologies are one example of a solution that can address the challenges and complexity caused by these features. Adding semantics to the information stored in systems makes the information more easily understandable for employees from different functions or organisations and may help to reduce the heterogeneity of services in case of change of service provider or the employees responsible for the service execution. People have a crucial role in service operations, so making information understandable for people is particularly important and can be reached through semantics. Intangibility of services complicates the task of defining service specifications. Through the semantic solution, access to information from several sources through one point is gained and more information is available for defining the specifications and quality requirements, which speeds up the process. Perhaps it will even be possible in the future to develop a ‘service structure’ analogical to product structure, i.e. which maintenance services are needed for which production equipment. (see Uusipaavalniemi *et al.* 2009).

It was also noted during the research process, that the annual overhaul shutdown should be considered both as a process and a project. The process view facilitates continuous development of the activities and procedures related to the annual overhaul. The project view emphasises that each annual overhaul is also an independent entity and has a beginning and end. The project view helps to identify the milestones along the project and gives a clearer view on the actors, activities, schedules, etc. A set of certain documentation needs to be completed in each project phase to demonstrate that the project goals have been reached. Also the maintenance information system should enable dealing with the annual overhaul as a separate project, but on the other hand as a part of the entire maintenance process.

To conclude, this study with its theoretical and empirical contributions enables better understanding and control of the service supply chain links, which in turn can improve the performance outcomes of the supply chain.

6.3 Reliability and validity of the study

Examining only one case supply chain may reduce the external validity, i.e. generalisability, of this study (see e.g. Yin 2003, Voss *et al.* 2002). However, multiple supply chain dyads were reviewed to address this problem. Although only one supply chain was examined, based on similar contextual setting groups of service provider companies could be formed and the findings from mechanical maintenance service provider companies could be combined and considered as a group, as well as the two service providers offering maintenance-related planning. This reduced the risk of possible biases such as misjudging the representativeness of a single event (see e.g. Voss *et al.* 2002, Leonard-Barton 1990).

As case studies rely on the analytical generalisation, with case study the generalisation is from each case towards broader theory (Yin 2003, Stuart *et al.* 2002). Time and space constitute a major restriction in generalising findings, but it does not mean that knowledge acquired in one context is of no relevance to other contexts or time frames (Erlandson *et al.* 1993). Halldórsson & Aastrup (2003) suggest considering transferability and contextualism as parallel criteria to external validity in naturalistic inspired, qualitative research. The idea behind this is that every phenomenon appears in a specific context. To understand or explain the phenomenon we must deal with the specific context, which makes generalisation across contexts problematic. (Halldórsson & Aastrup 2003). Thus, applicability of knowledge outside its context relies on the differences and

similarities between these contexts (Guba & Lincoln 1989). This principle should be kept in mind when seeking to apply the findings of this study in other research environments.

The validity in this research was ensured through multiple triangulation along four triangulation types (see e.g. Yin 2003, Denzin 1978):

- using multiple data collection methods in gathering information on the explored phenomenon (interviews, workshops, company visits, and company documents) ,
- having multiple data sources/informants (multiple informant groups, multiple informants from the same company, if possible) and thus e.g. combining the answers from different persons from different responsibility areas in the same company
- deploying triangulation related to researcher (having multiple researchers attend the data collection in workshops and during the company visits), and
- gaining theoretical triangulation, as several theoretical perspectives were reviewed when creating the conceptual framework of the study.

Although this study is more of a snapshot than a longitudinal study, the length of the study period (June 2006-August 2008) contributed to the validation of data. Observer bias was reduced by tape-recording the interviews, company visits and workshops and using multiple observers when possible (see e.g. Voss *et al.* 2002). The research reports and summary reports were sent to the informants/participants for verification after each research phase. Feedback from other case company representatives besides the respondents was received as the research reports were presented in the meetings of the steering group of the research project (face validity).

The researcher conducted all the structured interviews alone, which could be considered a weakness in the study. On the other hand, through this the researcher bias remained the same throughout the interviews. This also enabled a more relaxed and confidential discussion with the interviewees. Moreover, notes were taken during the interviews, the interviews were also taped and transcribed and the summary report of the interviews was sent to informants for verification in order to strengthen the validity (face validity). To enable inter-judging, the summary report of interviews was also sent to the other researchers of the project research group for verification. The workshops organised for company representatives also provided an opportunity for verification and clarification of

the research results obtained through the interviews and company visits (face validity).

Reliability of the study was strengthened by using a consistent set of interview questions and carefully documenting each research phase into a project database (e.g. Yin 2003). Halldórsson & Aastrup (2003) suggest that the dimension of reliability could in naturalistic inquiry be replaced with a parallel dimension termed dependability. Naturalistic research rests on an emerging research design instead of a priori design (Erlandson *et al.* 1993) and changes in design and constructs are seen as features of a maturing and successful inquiry and thus expected (e.g. Guba & Lincoln 1989). Dependability is achieved by documenting the logic and method decisions (Guba & Lincoln 1989).

6.4 Limitations and future research

Service supply chains in general have been neglected in research. Although this study brings a novel theoretical framework and new empirical data related to service supply chains, it has yet its restrictions. One limitation of this study is that in the empirical study only single case (one supply chain) was used. On the other hand, if multiple cases would have been used, the depth of the study might not have been adequate. In fact, Dubois & Gadde (2002) argue that when the problem studied is directed towards analysis of a number of interdependent variables in complex structures, a natural choice is to go deeper into one case instead of increasing the number of cases. However, more research across different cases in different service sectors should be carried out to eliminate the possible biases of this study. Examining more case supply chains from different service categories would probably provide substantial variation in the levels of integration and thus further support justifying and refining the theoretical framework. Moreover, a mixed industry approach would contribute to the generalisability of the theoretical model and empirical findings. There is also a need for comparing information integration in service supply chain and manufacturing supply chain to identify the possible differences and similarities. This would also enable the search for best practices in supply chains with integrated product-service packages.On the other hand, a differentiated approach to integration, as in this study, is supported by Fabbe-Costes & Jahre (2008) as it assists companies in identifying and focusing on a limited number of key integration elements.

Another restriction of this study is the limited time boundary, as this study was merely a snapshot. Thus, conclusions regarding developing information

integration are dependent on the time boundary, and gaining better understanding on the development process of information integration might be possible by extending the time boundary, i.e. conducting a longitudinal study (see e.g. Dubois & Gadde 2002).

Internal information integration was left out of the scope of this research although it is often considered as a prerequisite for external integration. Indeed, also in this study some of the problems related to information sharing in maintenance operations derived from the deficits in internal integration between different processes (mainly between production, purchasing, and maintenance) in the focal company. Interestingly, it has also been stated by Gimenez & Ventura (2005) that external integration should be understood as an incentive to internal integration. Either way, the problem areas related to internal integration should also be addressed before the information integration in the case service supply chain can be taken to the next level. After all, there is some evidence of internal and external integration having synergistic effects on performance (e.g. Dröge *et al.* 2004) and internal collaboration has been claimed to mediate the relationship between external collaboration and performance (Stank *et al.* 2001). Another view is that external and internal integration have an interactive effect on performance (Germain & Iyer 2006) and that lack of internal integration might prevent external integration from fully impacting performance (Germain & Iyer 2006). Also van Hoek & Mitchell (2006) have demonstrated that there are internal misunderstandings and disagreements on the opportunities and priorities within organisations, and suggest that the internal misalignment might explain the unsatisfactory success of supply chain efforts. Thus, the effect of internal integration should be covered in future service supply chain research.

Only a minority of supply chain studies explore both downstream and upstream integration (see e.g. van der Vaart & van Donk 2008). Some authors in SCM also argue that an integrated supply chain should include three or more echelons and thus examination of dyadic integration is not enough (e.g. Mentzer *et al.* 2001). This is also a limitation in this study. The scope of the study could be extended, for instance, to involve the customers of the steel manufacturer. Information shared between the focal company and its customers also relates to the maintenance operations and maintenance supply chain. Some generic information categories that affect both the customers' and maintenance service providers' operations include, for instance:

- Schedules of repairs. Repairs cause a shutdown at the production line and they are usually performed at times where there are less orders from customers, e.g. the annual reparations typically during the summer holiday season.
- Production quantities. The order quantities and thus production quantities affect the amount of wear of some parts at the production line and thus the maintenance interval.
- Product quality or other specific attributes related to the product. The special requirements may necessitate some adjustments to the production equipment.

Thus, the inclusion of the customer link could add new perspectives into the examination of service supply chain information sharing.

As maintenance operations in general are developed towards the more preventive and proactive view, a need for more knowledge-intensive services (more in the direction of consulting, proactive maintenance services) has been identified. Developing these kinds of services necessitates deep understanding of the customer's processes and the development of one's own competence. (Kallikoski *et al.* 2003). This further emphasises the meaning of information integration in service supply chains and necessitates reconsidering the level of integration needed. Moreover, recently the availability-based services (the service provider is responsible for the availability/usability of the customer's production line or a certain part of it) and performance-based services (e.g. Straub 2007) have been discussed in the literature. If the services in the case supply chain would be developed into this direction, the desirable level of integration should be radically reassessed. The suitability of the information integration framework used in this study for this type of services should also be carefully considered and the framework adjusted if needed.

It is clear that considerably more attention should be paid to developing information and knowledge sharing in service supply chains as information is critical in offering, delivering and evaluating services. Additional empirical research and theory building is needed to develop the service supply chain management genre further. More empirical research is needed to validate the model on contextual factors. The set of contextual factors could also be complemented through additional research. Moreover, the relative importance of each contextual variable and whether the importance varies depending e.g. on the service industry field should be further examined. This would provide guidance in situations where different contextual factors suggest contradictory levels of

integration for a supply chain dyad. Still, more evidence is needed considering whether the level defined by the contextual factors actually is the optimal level of integration for a supply chain dyad. To explicitly attest this, further research on links between the levels of integration and their performance effects should be carried out. This could facilitate creating models to match the information sharing needs, processes, systems and practices in different types of service supply chain dyads or service contracts. Moreover, no dyads representing the highest level of integration (level 3) were identified in the case supply chain of this study. Hence, additional research could better display the effect of context and performance outcomes in dyads with extensive integration.

The elements of information integration could be digged deeper: for instance research concerning information technologies that can especially address the challenges in information sharing caused by the special features of services is required. Also more research dealing with the inter-relations between the six elements of information integration presented in the framework of this study is needed. Existence of self-reinforcing interactions between these kinds of variables has been suggested and discussed in research (see e.g. Akkermans *et al.* 1999, Sheu *et al.* 2006). A question remains also, what exists beyond the level 3 integration. Will the information sharing then move again more towards informal communication? Indeed, a fundamental approach in organisational theory by Mintzberg (1979) suggests that when the complexity of work increases, the coordination mechanisms move from mutual adjustment through formalisation and standardisation again to mutual adjustment with more informal communication.

Due to the snapshot nature of this study, no direct empirical evidence to demonstrate the link between integration and supply chain performance was provided. There are, nevertheless, several ways to address the problematic related to the performance link in future research. To be better able to demonstrate the effects of individual integration elements, the links between service supply chain performance and the different elements should be further explored. Through this, perhaps certain combinations of performance effects associated with each element could be found. The performance effects of information integration were in this study assessed mainly from the perspective of operational performance. However, for instance Fawcett *et al.* (2007) have also considered in their study the competitive performance of supply chain companies (i.e. benchmarking against industry rivals). Perhaps assessing the *competitive* performance of the supply chain would give deeper insights to the performance aspects also in the service

context of this study. Furthermore, the performance effects in this study were based on perceptions by respondents and in order to obtain actual performance data, a longitudinal study examining the development of performance during a longer period of time would be needed (a longitudinal case study). This is an issue to be taken into account in the future research, as very few pieces of research in supply chain integration have used the actual performance data (Fabbe-Costes & Jahre 2008). There was also no proper difference made between the performance effects that could be gained in short term and the ones obtained only in long term. Finally, considering the nature of knowledge sharing as human behaviour, more 'soft' aspects to the management and measurement of performance could be added, such as human performance (Ives *et al.* 2003). However, demonstrating the performance link will still remain a challenging task, as many service-related performance measures are based on perceptions of the actors in a supply chain and the perceptions may vary between different organisations and individuals.

To conclude, this study has increased our knowledge on the complex and multidimensional phenomenon of information integration in a yet quite unexplored context of service supply chains. Future research will hopefully be able to validate and refine the propositions of this study in various other service supply chain settings.

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Appendix 1 Interview questions for the focal company

Background information

- Interviewee
- Position of the interviewee in the company
- Production line
- Person(s) responsible for the maintenance of the production line
- Maintenance organisation related to the production line
  - Number of employees in operative work
  - Number of supervisors/management
- Timing and duration of the annual overhaul at the production line this year (2007)
- Number of companies (service providers) involved in the maintenance work/the annual overhaul
- Names of the companies (service providers) involved
- Number of people involved in the maintenance work during the annual overhaul
  - Employees in operative work
  - Supervisors/management
- What are the most critical equipment/devices in maintenance of this production line?
- What information systems generally are utilised related to the maintenance of the production line? Who (which group(s) of actors) are the users? What kind of maintenance-related information exists in these systems (essentially)?

I Information sharing before the annual overhaul (planning)

- What kind of tasks and preparations your company has to perform before the annual overhaul begins (in the planning stage)? Who are responsible for these activities related to this production line?
- How long do the preparations and planning of the annual overhaul take in total (did take this year)? (time span, man-hours needed)
- How well in advance before the annual overhaul you typically start in your company the planning/preparations (e.g. the planning of timetables, tasks, resources, etc.)?
- How well in advance before the annual overhaul you typically start in your company informing the employees participating in the planning and implementation of the maintenance work and arranging work/planning meetings?
- In general, what information is needed for the annual overhaul in the planning stage? Where do you get it from, when and how (e.g. from

information systems, documents, orally, through phone calls, meetings (how often?) etc.)?

- What information related to the annual overhaul do the external service providers need before the annual overhaul? Where do they get it from (from your company, from other external organisations, etc), and when and how (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What information does your company need to get from the external service providers before the annual overhaul? Where do you get it from (from your company, from other external organisations, etc., and when and how (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)?
- Do the external service providers (or other actors in the annual overhaul) have access to your company's information system(s) before the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Does your company have access to some of the external service providers' information systems before the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s) of which companies?
- Do you have consistent, commonly agreed practices for information sharing before the annual overhaul inside your own company and with the external service providers or do the practices vary depending on the actors involved? Can you describe the practices shortly? Are the practices documented?
- What information systems and technological/computer tools are utilised in your company before the annual overhaul regarding the preparation and planning of the annual overhaul? Or to what kind of systems is information entered?
- How is the operation of the production line monitored/controlled before the annual overhaul? (What parameters and measures are used, are these compared to previous data, etc.). (For instance, production quantities, operating time ratio).
- Is there some information that you currently do not get before the annual overhaul, but that you would consider beneficial when planning and preparing the annual overhaul? What information is it and from where/whom and how could you possibly get it?
- What factors slow down or hinder the information sharing between your company and the external service providers before the annual overhaul?
- How could the information sharing occurring between your company and the external service providers before the annual overhaul be developed? What kind of performance effects would these developments have?

II Information sharing during the annual overhaul (implementation)

- In general, what information is needed for the annual overhaul during it? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What information does your company need to get from the external service providers during the annual overhaul? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What information related to delivering their services do the external service providers need to get from your company (or potentially other parties involved) during the annual overhaul? Where do they get it from (from your company, from other external organisations, etc), and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What are the most common problems at the production line during the annual overhaul that can be partly or entirely attributed to inadequate flow of information/poor information sharing? (problems in the co-operation between your company and the external service providers)
- What kind of problems and changes occurred during this year's (2007) annual overhaul? (generally and related to information sharing)
- Do typically many changes occur during the annual overhaul related e.g. to the schedules, tasks, resources, etc.? Which changes are most typical? What is the procedure to handle these change situations and is it documented?
- To whom, how and how fast the changes are communicated? Does the information reach effectively also the external service providers, if needed?
- What is the way of action used, if there will be, for instance, a need for additional, unplanned maintenance work during the annual overhaul? (e.g. new failures or worn out spare parts are detected). How is the information spread, how the responsibilities divided, etc.?
- Do you consider that the practical problems and change situations between your company and the external service providers are easy to solve? Is there a common procedure for solving the problem situations? Describe the procedure in practice.
- Is it easy for the employees of your company and employees of the external service providers to understand each other, or are there, for instance, differences in concepts between the companies or inside your company between various departments/processes?
- Do you have consistent, commonly agreed practices for information sharing inside your own company and with the external service providers during the annual overhaul or do the practices vary depending on the actors involved? Can you describe the practices shortly? Are the practices documented?
- How do you control the progress and success of the annual overhaul (e.g. schedules, safety, resources, etc.) during the annual overhaul? Are these

issues reported somehow inside your company and to the external service providers?

- How do the external service providers report to your company about the services they are delivering (the tasks that they have completed, problems that have occurred, possible changes, etc.)?
- What information systems and technological/computer tools are utilised in your company during the annual overhaul? Or to what kind of systems is information entered?
- Do the external service providers (or other actors in the annual overhaul) have access to your company's information system(s) during the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Does your company have access to some of the external service providers' information systems during the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s) of which companies?
- Is there some information that you currently do not get during the annual overhaul, but that you would consider beneficial for the performing and managing of the maintenance work in the annual overhaul? What information is it and from where/whom and how could you possibly get it?
- What factors slow down or hinder the information sharing between your company and the external service providers during the annual overhaul?
- How could the information sharing occurring between your company and the external service providers during the annual overhaul be developed? What kind of performance effects would these developments have?

III Information sharing after the annual overhaul (control and feedback)

- What kind of activities/tasks your company has to perform related to the annual overhaul after it (e.g. reporting etc.)? Who are responsible for these activities related to this production line?
- How long do these activities/tasks performed after the annual overhaul take in total (did take this year)? (time span, man-hours needed)
- In general, what information is needed for the annual overhaul after it? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What information related to delivering their services do the external service providers need to get from your company (or potentially other parties involved) after the annual overhaul? Where do they get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What information does your company need to get from the external service providers (or potentially from other parties involved) after the annual overhaul? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)

- Do you have consistent, commonly agreed practices for information sharing inside your company and with the external service providers after the annual overhaul or do the practices vary depending on the actors involved? Can you describe the practices shortly? Are the practices documented?
- What information systems and technological/computer tools are utilised in your company during the annual overhaul? Or to what kind of systems is information entered?
- Do the external service providers (or other actors in the annual overhaul) have access to your company's information system(s) after the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Does your company have access to some of the external service providers' information systems after the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s) of which companies?
- After the annual overhaul, how do you control the success of the maintenance work and services? Do you, for instance report on the actually realised schedules, possible problems and disturbances that have occurred, extra tasks, etc. after the annual overhaul?
- To whom (which group(s) of actors) or where (system(s), archives, written reports, etc.), how and when is this follow-up data mediated? Inside your company and to the external service providers?
- How does your company utilise the follow-up data and possible feedback from the annual overhaul? (For instance, in the planning of next year's annual overhaul or other maintenance activities, etc.)
- Is there some information that you currently do not get after the annual overhaul, but that you would consider beneficial for the evaluation and control of the maintenance activities (or respectively in planning and implementing the maintenance activities in future)? What information is it and from where/whom and how could you possibly get it?
- What factors slow down or hinder the information sharing between your company and the external service providers after the annual overhaul?
- How could the information sharing occurring between your company and the external service providers (and inside your company) after the annual overhaul be developed? What kind of performance effects would these developments have?

Appendix 2 Interview questions for service providers

Background information

- Name of the service provider company
- Company's branch of industry
- Interviewee
- Position of the interviewee in the company
- Number of employees in the company
  - In total
  - In the local unit
- Dates of delivering the services related to the focal company's annual overhaul this year (2007)
- How many employees from the company were involved in planning and delivering the services provided to the focal company this year (2007)
- The number of customers your company (the local unit) has? What kind of customer companies are they (industry, size, etc.)?
- How important/big customer is the focal company to your company? (e.g. key customer, one of the biggest customers, the duration of the co-operation, etc.)
- Is the co-operation between your company and the focal company
  - occasional
  - regular, contract-based
  - continual, with long-term contracts
- What kind of services/task entities your company is providing to the focal company?
- What kind of services/task entities was your company providing to the focal company related to this year's (2007) annual overhaul?

I Information sharing before the annual overhaul (offering and planning the services)

- What kind of tasks and preparations your company has to perform before the annual overhaul begins (in the planning stage)? (planning the tasks, resources, etc., possible meetings with the focal company)
- How long do the preparations and planning of the services related to the annual overhaul take in total (did take this year)? (time span, man-hours needed)
- How well in advance before the annual overhaul you typically start in your company the planning/preparations (first of all the quotation, and after gaining the contract the planning of schedules, tasks, resources, etc.)?

- How well in advance before the annual overhaul you typically start in your company informing the employees participating in the planning and delivery of the services and arranging work/planning meetings?
- What information related to your services you need to get from the focal company (or potentially other parties involved) before the annual overhaul? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What information does the focal company need to get from your company before the annual overhaul? Where do they get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- Do you need some information from other actors besides the focal company before the annual overhaul? What information? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- Does the focal company (or other actors in the annual overhaul) have access to your information system(s) before the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Does your company have access to some of the focal company's information systems before the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Do you have consistent, commonly agreed practices for information sharing with the focal company before the annual overhaul or do the practices vary? Can you describe the practices shortly? Are the practices documented?
- What information systems and technological/computer tools are utilised in your company regarding the preparation and planning of services related to the annual overhaul? Or to what kind of systems is information entered?
- Is there some information that you currently do not get before the annual overhaul, but that you would consider beneficial for your company when planning and preparing services for the annual overhaul? What information is it and from where/whom and how could you possibly get it?
- What factors slow down or hinder the information sharing between your company and the focal company before the annual overhaul?
- How could the information sharing occurring between your company and the focal company before the annual overhaul be developed?

II Information sharing during the annual overhaul (delivering the services)

- In general, what information your company needs to be able to deliver your services during the annual overhaul? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What information does the focal company need to get from your company during the annual overhaul? Where do they get it from, and how and when

(e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)

- What information related to delivering your services does your company need to get from the focal company (or potentially other parties involved) during the annual overhaul? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- What are the most common problems in the co-operation between your company and the focal company that can be partly or entirely attributed to inadequate flow of information/poor information sharing?
- What kind of problems and changes occurred during this year's annual overhaul? (generally and related to information sharing)
- Do typically many changes occur during the annual overhaul related to the schedules, tasks, resources, etc.? Which changes are most typical? What is the procedure to handle these change situations and is it documented?
- To whom, how and how fast the changes are communicated?
- Do you consider that the practical problems and change situations between your company and the focal company are easy to solve/cope with? Is there a common procedure for solving the problem situations? Describe the procedure in practice.
- Is it easy for the employees of your company and employees of the focal company to understand each other, or are there, for instance, differences in concepts?
- Do you have consistent, commonly agreed practices for information sharing with the focal company during the annual overhaul or do the practices vary? Can you describe the practices shortly? Are the practices documented?
- How do you control the progress and success of your services/tasks (e.g. schedules, safety, resources, etc.) during the annual overhaul? Are these issues reported somehow inside your company?
- How do you report to the focal company about the tasks that you have completed, problems that have occurred, possible changes, etc.?
- What information systems and technological/computer tools are utilised in your company regarding the delivery of your services during the annual overhaul? Or to what kind of systems is information entered?
- Does your company have access to some of the focal company's information systems during the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Does the focal company (or other actors in the annual overhaul) have access to your information system(s) during the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Is there some information that you currently do not get during the annual overhaul, but that you would consider beneficial for your company in delivering the services for the annual overhaul? What information is it and from where/whom and how could you possibly get it?

- What factors slow down or hinder the information sharing between your company and the focal company during the annual overhaul?
- How could the information sharing occurring between your company and the focal company during the annual overhaul be developed?

III Information sharing after the annual overhaul (control and evaluation of the services, feedback)

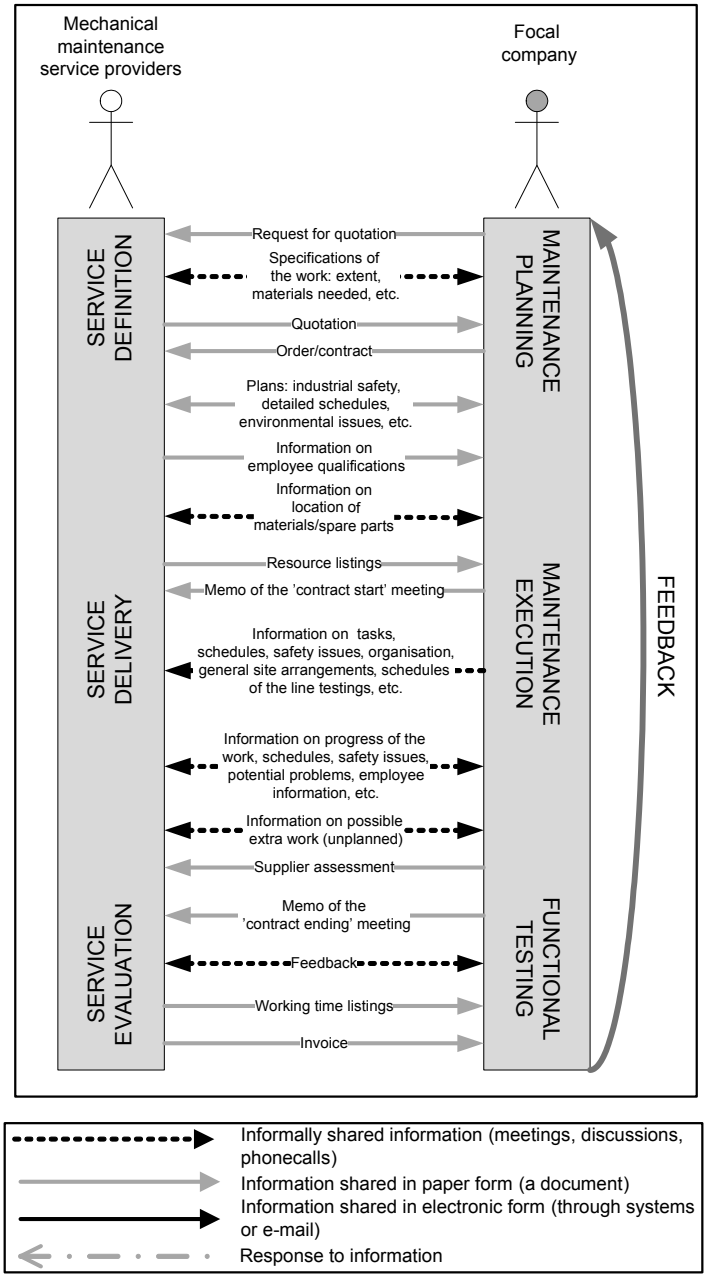
- What kind of activities/tasks your company has to perform related to the services you have delivered after the annual overhaul (e.g. reporting related to a contract etc.)?
- How long do these activities/tasks performed after the annual overhaul take in total (did take this year)? (time span, man-hours needed)
- Does the focal company need to get some information related to the services delivered from your company after the annual overhaul? What kind of information? Where do they get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- Does your company need to get some information (related to the services delivered) from the focal company (or potentially from other parties involved) after the annual overhaul? What kind of information? Where do you get it from, and how and when (e.g. from information systems, documents, orally, through phone calls, meetings (how often?) etc.)
- Do you have consistent, commonly agreed practices for information sharing with the focal company after the annual overhaul or do the practices vary? Can you describe the practices shortly? Are the practices documented?
- What information systems and technological/computer tools are utilised in your company regarding your delivered services after the annual overhaul? Or to what kind of systems is information entered?
- Does the focal company (or other actors in the annual overhaul) have access to your information system(s) after the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- Does your company have access to some of the focal company's information systems after the annual overhaul? Who (which group(s) of actors) has/have the access and to which system(s)?
- After the annual overhaul, how do you control the success of the services you delivered? Do you, for instance report on the actually realised schedules, possible problems and disturbances that have occurred, extra tasks, etc. after the annual overhaul?
- To whom (which group(s) of actors) or where (system(s), archives, written reports, etc.), how and when is this follow-up data mediated?
- How does your company utilise the follow-up data and possible feedback from the annual overhaul? (For instance, in the planning of other contracts, etc.)

- Is there some information that you currently do not get after the annual overhaul, but that you would consider beneficial for your company in evaluation and control of the services delivered (or respectively in planning and delivering the forthcoming services)? What information is it and from where/whom and how could you possibly get it?
- What factors slow down or hinder the information sharing between your company and the focal company after the annual overhaul?
- How could the information sharing occurring between your company and the focal company after the annual overhaul be developed?

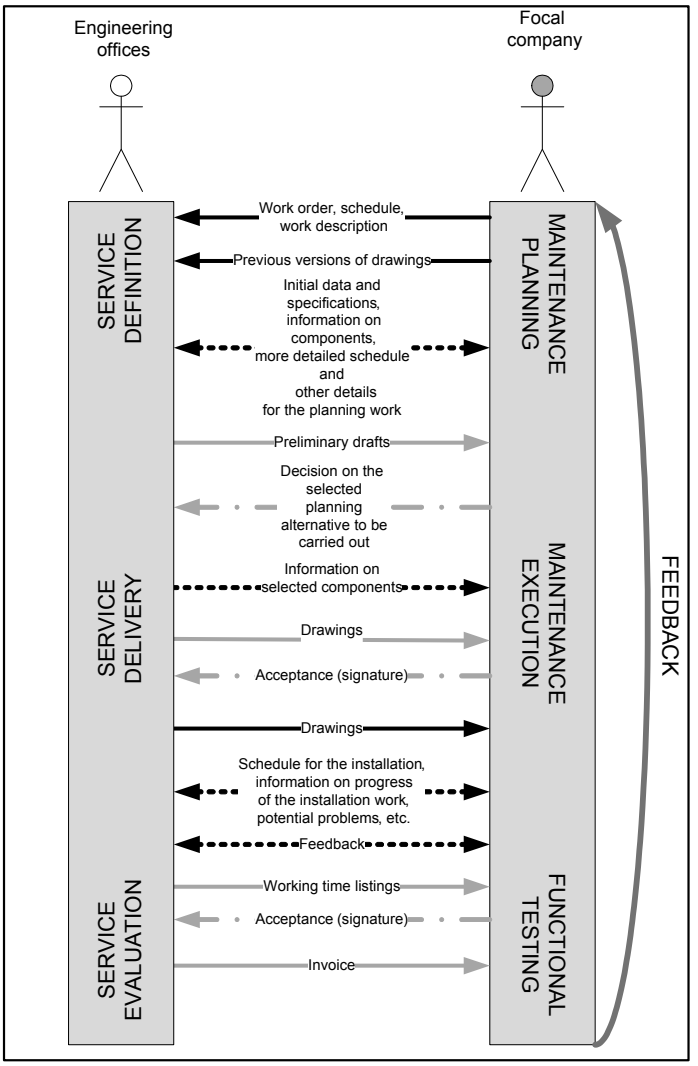
Information sharing and performance

- What kind of effects would improvements in information sharing between your company and the focal company have on your company's performance or your services?
- What about the effects on the performance of your customer company, the focal company (and specifically the maintenance process)?
- Could/should (some of) the information shared between your company and the focal company be shared in some other form than it is currently shared?
- Do you consider that the information from the focal company is available easily and fast enough?
- Do you generally consider the current quality of the information received from the focal company adequate? (information is accurate, useful, reliable, and complete enough)
- What factors facilitate the information sharing between your company and the focal company?

Appendix 3 Information flows in MM-FC dyads



Appendix 4 Information flows in EO-FC dyads



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