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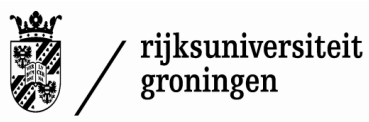

The Role of ICT in Supply Chains

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September 2012

Xuan Zhang

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CHAPTER 1

INTRODUCTION

Case 1:

Youngor, a leading company in the Chinese garment industry, won the 2008 award of the most competitive brand in China. Mr. Li Rucheng, who is the CEO of Youngor, attributed this big success to the application of ICT. Around 2000, with the increasing competition in the clothing market and the growing demand of customers, Youngor could no longer meet market demand. At the same time they were confronted with operational problems like overcapacity and excess stocks. Facing declining profits, the executive decided to build their own supply chain management system and to become more responsive to market demand. Youngor invited Professor Han Yongsheng, who is the expert in the MIS field, to guide the firm information process. In the first stage, Youngor has invested more than €12 million into the ICT.

According to the features and special application requirements, Youngor developed a CAD system, a DRP system and an ERP system. With these systems in place Youngor was able to manage and control the entire flow from purchasing, through manufacturing and delivery to selling. In addition, Youngor provided the customized products besides standard products to the customers. Each store of Youngor used a POS system to record the information of customers and sales. It also had an ordering system that generated the orders according to the demands and forecast. In addition, Youngor build a data center to deal with the information from more than 2000 shops and 400 distribution centers. Every day the shop managers updated the data captured from the POS system into the data center and they used IBM Cognos to analyze the data. With the IBM Cognos they were able to extract the important information from the huge amount data of the data center, to do multi-dimensional analyses, and to report the results by means of graphical presentations. By processing this system, the managers can find the problems and affirm the causation, which help them to monitor the market and make the right decisions.

In addition, Youngor also cooperated with its suppliers to develop VMI (Vendor Managed Inventory) and CPFR (Collaborative Planning, Forecasting and Replenishment) to achieve quick response. With the support of ICT, Youngor is able to operate with lower cost, more quick response, and higher service levels than ever before. Until 2006, the stock was reduced by 30%, which accounted for a € 25 million saving in costs. The complex ordering and purchasing process became automated, and as a result the cost of human failures had been decreased by 20%. The firm improved its responsiveness and reduced the time of the whole process from designing to delivering by 55.6%. Furthermore, the customized order system brought more than € 20 million income for Youngor in 2003.

With the help and support from ICT, Youngor has achieved an outstanding performance and demonstrated potential. In 2008, Youngor purchased Smart Shirt from the American company Kellwood, further enhancing its capabilities in design and management. Through this purchase, it also acquired an US-wide distribution network, making it one of the biggest integrated textile and garment businesses in the world. With the synergy between upstream and downstream innovation, Youngor is well-positioned to become even more competitive in an international market (Captured from http://www.youngor.com).

Case 2:
Sanlu is a famous professional cosmetics enterprise which has integrated the development, production and marketing of its products. Sanlu's products were known for excellent quality and low prices. To deal with a huge increase in sales volumes of their products, Sanlu started to restructure the supply chains of all its businesses in order to be able to adapt to changes in a quicker and more effective way. This first action of Sanlu for this strategy was to implement an ERP system.

Sanlu chose Lenovo as provider of the ERP software. At that time, Lenovo adopted the MOVEX system of Sweden Intentia Co., Ltd. However, Lenovo was not familiar with the MOVEX system, which led to a whole process of installing and debugging which did not follow the standard established by Intentia. As a result the software was not able to run smoothly. Furthermore, Lenovo did not customize the ERP system well. Firstly, the operation interface was not fully translated to Chinese. Secondly, the input data and the reports generated by the software did not match with the demands and formats of the Chinese financial system. These shortcomings made the employees of Sanlu face many problems in the actual use of system, and as a result many employees stopped using it. Besides the unsatisfactory performance of Lenovo, the internal investigation after the implementation revealed that Sanlu itself was also responsible for the failure of the ERP project. For example, the top managers did not pay sufficient attention to the project. The managers did not communicate with the engineers of Lenovo and did not make their requirement for the ERP system clear, which led Lenovo to develop the system without a good fit with the operational processes of Sanlu.

On the 31st of July 2001 Sanlu announced that its revenues had decreased with 4.3% to €3.4 million compared to the same quarter in 2000. The company attributed this fall in revenues mainly to the problems faced in migrating to a centralized ERP system. The failure demonstrated the adverse financial and business impact of poor ERP implementation. The managers from Sanlu and Lenovo said "It's surprising that good software could take a company down like this. It doesn't get more embarrassing than that." After the introspection of the failure, Sanlu decided to continue with a new provider of ERP systems. In 2002, Sanlu chose Hejia software company as ERP provider after detailed comparison and consideration. By implementing this ERP system, Sanlu realized the integrative management of purchasing, selling, stocking, manufacuring and financial accounting. Recently, Sanlu began the development and application of the electronic commerce system of Heija.

1.1 Introduction

These two cases represent two of the companies that took part in the survey conducted in the PhD project. The differences in the benefits of information and communication technology (ICT) in these two cases indicate that the role of ICT in improving SC (supply chain) performance is a complex one. Both the industry and the academia have noticed the importance of the topic of ICT-business value, as the introduction of ICT has not only changed our daily lives but also the face of communication in the modern business world.

On the one hand, ICT has resulted in many new business models usually entitled as the "new economy". It boomed some emerging industries and companies including ICT service providers and ICT equipment manufacturers, like Amazon, Microsoft and Dell. On the other hand, ICT has been widely used in traditional industries and changed the structures and management of firms, and especially the processes within firms. As illustrated in the first case above and some well-known companies (e.g. Zara, Wal-Mart), ICT can be an enabler of operation or supply chain management (SCM) and improves the performance of firms. However, the experiences from other firms (e.g. Case 2) showed that ICT is not a silver bullet for all companies seeking performance improvements or competitive advantage. Umble and Umble (2002) indicated that between 50 and 75 percent of U.S. firms experience some degree of failure when implementing advanced manufacturing or information technology. ICT investment and its output as expressed in the debate are entitled "the ICT productivity paradox" (Brynjolfsson et al., 2000). This paradox has placed managers in an awkward situation. On the one hand, firms can not afford not to invest in ICT and they are always inspired to spend more money on ICT. On the other hand, ICT does not always work as they expected.

Nowadays, competition is no longer company to company but supply chain to supply chain (Christopher, 2011). Organizations increasingly find that they have to rely on effective supply chain management to compete in the global market and networked economy. Supply chain management helps organizations to integrate systemically the traditional business functions and the process across organizational boundaries to help companies improve the long-term performance (Mentzer et al., 2000). ICT, which is capable of processing large amounts of data and enables long-distance communication, is essential for supply chain management. That is why firms need to invest in ICT and they are often tempted to spend more money on ICT. However, they cannot always find sufficient justification from an economic perspective, and the evaluation of practices is not always providing enough support for making the investment. Sometimes the companies have made investments in ICT, but they are still searching how to apply ICT to achieve actual improvements in their SC performance. One of the executives who participated in the survey conducted for this PhD-project describes the problem as follows: "Our company plans to invest in ICT, because other firms seem to benefit from their ICT systems. We decided to buy the same one and hope it will prove to be beneficial for us too. But actually we have not fully investigated whether it is also suitable for us and how the systems work. In total we have spent more than two millions Euros on ICT, including buying various types of infrastructures and systems, and training employees. However, our company is generally unsuccessful in applying ICT to achieve advantages. ICT brings much less benefits than our expectation and even has caused some serious troubles. For example, it took more than 6 months to coordinate the data format of our new information system with our supply chain partners, which led to enormous production delays".

Although there seems to be consensus that ICT is fundamental to successful supply chain management, it is still unclear how ICT impacts on SC performance. In line with this remark, Van Donk (2008) notes that much money is actually spent in buying, implementing, running and updating ICT in all its diversity, but that we do not clearly know what the effects are, how to implement ICT and what relevant factors should be considered. To fill this gap, this dissertation aims to explore the underlying mechanism that connects ICT to SC performance.

In the remainder of this chapter, we firstly discuss the prior research on ICT value and relevant theories. Secondly, we discuss research on the impact of ICT on SC performance. Because the data collection took place in China, we proceed with some background on the Chinese context in which the research took place. Finally, we explain the structure of the thesis and the content of its chapters.

1.2 Background

In the background part, we first discuss earlier research on ICT value in general. Then, we specifically discuss studies on ICT value for supply chains and correspondingly propose a conceptual model for our research. Finally, based on the model the relevant research questions are identified.

1.2.1 Prior research on ICT value

Earlier studies on ICT value focus on the ICT payoff at the level of both the national economy and industrial sector. Scholars analyzed the relationship between ICT investment and the economic increase or productivity, but most studies did not find any effect (e.g. Strassman, 1985). These studies discussed the relationship between the average ICT investment and the average outcome at the national or industrial level. However, the performance of ICT in different firms is likely to differ (Brynjolfsson et al., 2002). For companies and managers it is probably more relevant to know whether and how ICT helps in improving their performance or/and increases their competitive advantage. Therefore, it makes sense that later studies focused on the impact of ICT at the company level. Scholars have adopted various theoretical paradigms in examining the impact of ICT on organizational performance, including microeconomics, industrial organizational theory, sociological perspectives, and the resource-based view.

Microeconomic theory provides a rich set of well defined constructs interrelated via theoretical models and mathematical specifications. Researchers have applied growth accounting (Jorgenson and Stiroh, 1999), consumer theory (Hitt and Brynjolfsson, 1996), Tobin's q (Bharadwaj et al., 1999) and option pricing models (Benaroch and Kauffman, 1999) to enable estimation of the economic impact of ICT and the uncertainty of ICT investments. The assumptions of microeconomic-based methods must be carefully assessed within the specific research context (Melville et al., 2004), thus its application within ICT business value

research has limited value in explaining actual phenomena. Some other studies apply

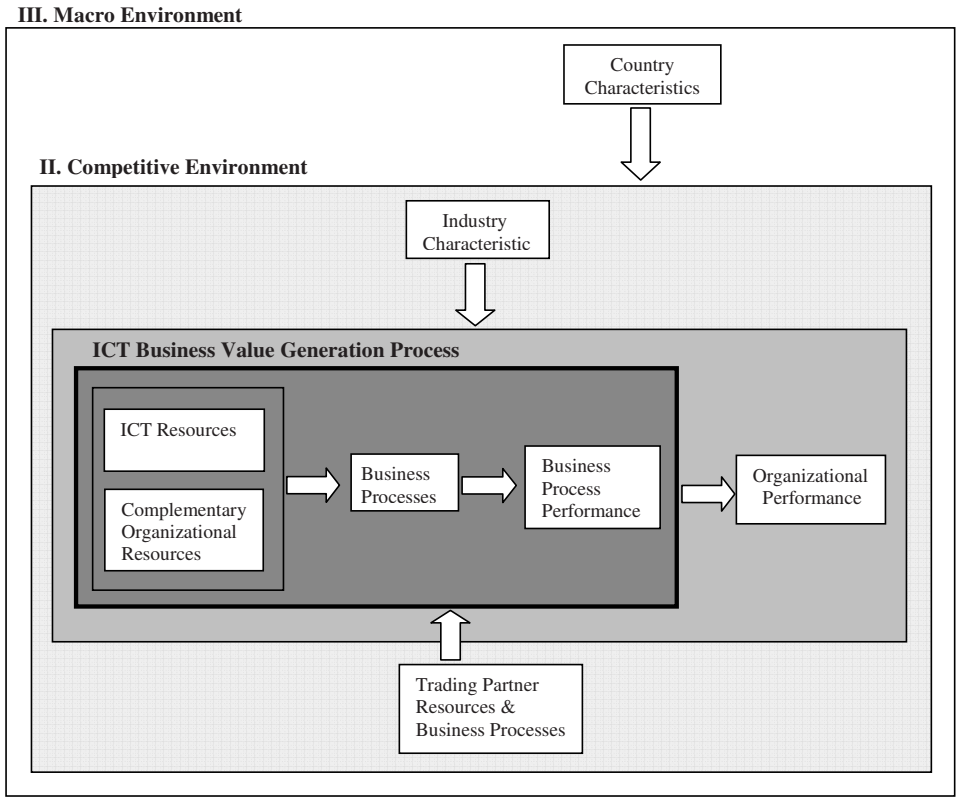

Figure1.1 ICT Business Value Model (Source, Melville et al., 2004, p. 293)

industrial organizational theory to examine how firms jointly interact with their partners in ICT investments decisions and how the payoffs are distributed (Melville et al., 2004). For instance, transaction cost theory helps to understand the role of ICT in decreasing transaction costs (Clemons and Row, 1991; Gurbaxani and Whang, 1991). Game theory has been used to examine the role of strategic interaction among competitors in ICT business value generation and capture (Belleflamme, 2001). These studies take the maximization of organizational efficiency and effectiveness through ICT as the common goal of all organizational stakeholders (Kling, 1980). There is another stream that regards ICT application as the economic activity embedded in social networks (Granovetter, 1985). Within this stream researchers apply a sociological perspective to understand how inter-organizational relationships influence ICT business value (Chatfield and Yetton, 2000) or how ICT affects the relationships between organizations (Kumar et al., 1998).

The above theories increased our understanding of ICT business value from diverse perspectives, but the absence of a unified theoretical framework has led to a fractured research

stream with many simultaneous but non-overlapping debates (Chan, 2000). The Resource-Based View (RBV) is grounded in the economic perspective and is concerned with firm heterogeneity and imperfect competition (Barney, 1986). The RBV provides a unified theoretical framework which can be used to study the rich contextual processesassociated with ICT business value (Melville, 2004). ICT researchers apply RBV to conceptualize how ICT relates to a firm's competitive advantage and performance (Mata et al., 1995), and to assess empirically the complementarities between ICT and other firm resources (Powell and Dent-Micallef, 1997). The theory also provides a basis to consider the connection or relationship between ICT and non-ICT resources. In other words, the RBV facilitates studies on the interaction between ICT assets or capabilities and other non-IT components (Jeffers, 2008). Based on the RBV, Melville et al. (2004) developed an integrative framework to explain the underlying mechanisms of ICT business value (see Figure 1.1).

In this framework the locus of ICT business value generation comprises three domains: focal firm, competitive environment and macro environment. Using the resource-based view as a primary theoretical lens, the model describes how phenomena resident within each domain shape the relationship between ICT and SC performance. In summary, the framework reveals that:

(1). ICT impacts organizational performance via intermediate business processes. When ICT implementation incorporates business process in the right way, it will lead to improved processes and then improve organizational performance.

(2). ICT also can be moderated or mediated by other organizational resources such as workplace practices, to be able to have its impact on organizational performance;

(3). The external environment plays a role in ICT business value generation (Melville et al., 2004).

In a summary of the empirical literature of ICT business value on a firm level, Wade and Hulland (2004) (Table 1.1) found that in some cases ICT has a direct effect on performance as well as an interaction effect with other variables. In other cases, ICT has no or even a negative relationship with competitive advantage or performance.

Table 1.1 Summary of the Effects of ICT on Firm Performance

Outcome effect	Relevant Studies
Direct and Positive ICT has a direct and positive effect on competitive advantage or performance	Banker and Kauffman (1991); Bharadwaj (2000); Clemons and Weber (1990); Floyd and Wooldridge (1990); Jelassi and Figgon (1994); Mahmood (1993); Mahmood and Mann (1993); Mahmood and Soon (1991); Roberts et al. (1990); Silverman (1999); Tavakolian (1989); Tyran et al. (1992);Yoo and Choi (1990)
Direct and Negative ICT has a negative effect on competitive advantage or performance	Warner (1987)
No Effect ICT has no impact on competitive advantage or performance	Sager (1988); Venkatraman and Zaheer (1990)
Contingent Effect The effect of ICT on competitive advantage or performance depends on other constructs	Banker and Kauffman (1988); Carroll and Larkin (1992);Clemons and Row (1988); Clemons and Row (1991);Copeland and McKenney (1988); Feeny and Ives (1990);Henderson and Sifonis (1988); Holland et al. (1992);Johnston and Carrico (1988); Kettinger et al. (1994); Kettinger et al., (1995); King et al., (1989); Lederer and Sethi (1988); Li and Ye (1999); Lindsey et al. (1990); Mann et al. (1991); Neo (1988); Powell and Dent-Micallef (1997); Reich and Benbasat (1990); Schwarzer (1995); Short andVenkatraman (1992)

* Source Wade and Hulland (2004), p.125

Based on the framework presented in Figure 1.1 in the previous section, we conclude that one of the main explanations for the conflicting results might be that the extent and dimensions of ICT's value are dependent on internal and external factors, including complementary organizational resources of the firm and its trading partners, as well as the competitive and macro environment (Melville et al., 2004). Therefore, the failure in finding the impact of ICT on performance lies not within the technology itself but with how ICT is implemented and how the relationship is investigated (Bakos and Jager, 1995).

Another explanation can be found in the literature on management information systems (MIS). According to Willcocks and Lester (1996) the results in this field are not in line because different studies recognize and measure ICT in different ways. In ICT value research, three main conceptualizations of ICT have been adopted (1) the tool view, (2) the proxy view, and (3) the ensemble view (captured from Orlikowski and Iacono, 2001).

In the tool view, ICT is regarded as the entity that does what its designers intended, for example, to manage the stock level or to generate the production plan. This view is frequently used within ICT value research (e.g. Banker and Kauffman, 1991; Bharadwaj, 2000). Studies that discuss specific systems enable examination of the tool view assumption.

In the second conceptualization – the proxy view –, ICT is conceptualized by its essential characteristics, which are defined by its usefulness or value, the diffusion of a particular type of system within a specific context, and its investment or capital stock denominated in financial units (Melville et al., 2004). Researchers often adopt this conceptualization in empirical studies for ICT measurement (e.g. Silverman, 1999).

The ensemble view is the third conceptualization, assessing the ICT value generation in a rich context. This view discusses the interaction of people, organization and technology in both the development and use of ICT (Orlikowski and Lacono, 2001). Therefore, organizational structure and co-innovation such as workplace practices may be included as moderators or mediators of ICT value (e.g. Short and Venkatraman, 1992; Schwarzer, 1995). Ross et al. (2005) indicate that the competitive advantage of firms stems from their ICT capabilities not just from ICT per se. ICT capability is the ability of an organization to deploy ICT in combination with other resources in the firm. It is related to ICT infrastructure, human IT resources, knowledge assets etc. (Bharadwaj, 2000).

The conceptualizations of ICT reveal that ICT business value research can be characterized by a diversity of different approaches in understanding ICT and ICT constructs. This diversity could easily lead to different research outcomes. Moreover, in the MIS field many scholars categorize ICT into different types according to their characteristics, for example, according to the scope of ICT application, leading to a distinction between inter- and intra-organizational ICT. These different categories are manifested in the way ICT is used (De Sanctis and Poole, 1994). Recent research suggests that the pattern of ICT use is a contributor to differing outcomes (Subramani, 2004). Taken together, it is inferred that the different types of ICT would have a different impact on firm performance. Thus, it is important to disaggregate the ICT construct into meaningful subcomponents for ICT value studies. However, to date the existing ICT value studies do not consider this issue fully. Most studies discuss ICT as a whole entity instead of different categories, and therefore do not help us to clearly understand the generation of ICT business value.

1.2.2 Research on the impact of ICT on supply chain

With the internationalization and globalization of markets, firms have to improve operational capabilities to cooperate with their suppliers and customers to beat the competition. Therefore, supply chain management has increasingly gained attention (Chen and Paulraj, 2004). Supply chain management is the process by which suppliers, partners, and customers plan, implement and manage the flow of information, services, and products in a way that improves business operations in terms of speed, agility, real-time control, or customer response (Zhang and Dhaliwal, 2009, p. 252). The philosophy of supply chain management is founded on integration among supply chain partners (Narasimhan and Jayaram, 1998; Vakharia, 2002; Prahinski and Benton, 2004). The central issue with integration is the

exchange of large amounts of information along the supply chain, including various kinds of real-time information (Sanders, 2008). ICT allows for the sharing of large amounts of information and the processing of information necessary for synchronous decision making (Kearns and Lederer, 2003). Therefore, some researchers regard ICT as the backbone of supply chain management (Sanders, 2007). As a result, scholars have begun to pay attention to the relationship between ICT and SC performance.

In section 1.2.1 we discussed the literature with respect to the ICT business value on the firm level. A natural question is if the reported results and insights on the firm level with respect to how ICT helps to create value in companies can be directly transferred to the impact of ICT on supply chains and SC performance. To be able to answer this question, we first have to clarify the concepts of the supply chain and supply chain management.

A supply chain is a bidirectional flow of information, materials and services between the initial suppliers and final customers through different organizations (Cooper et al., 1997). Supply chain management is defined as the planning and control of materials and information flows as well as logistics activities not only internally within a company but also externally between companies (Cooper et al., 1997; Fisher, 1997). Supply chain management creates a virtual organization composed of several independent entities with a common goal (Tan, 2001). The concept of the supply chain is inspired by the intense competition between firms. It is not enough to achieve a competitive advantage by a single firm. Companies are required to integrate within a network of organizations. This has consequences for the focus of research on ICT value in a supply chain. On the one hand, a supply chain still has the form and characteristics of an organization. Therefore, we submit that theories used to analyze ICT value at the firm level are still suitable for analyzing ICT value for a supply chain. On the other hand, supply chains have specific features as they span and cross several companies. Thus, when discussing the impact of ICT on supply chain, studies should incorporate the supply chain perspective including the related supply chain activities and processes.

Reynolds (2000) noted that academic research on ICT value for supply chains is lagging behind and that systematic and comprehensive research is needed. The framework presented in section 1.2.1 provides an integrative view for the studies on the impact of ICT on firm performance. Since the supply chain can be regarded as a virtual organization, the logic and structure of this framework can be migrated to supply chains. However, the relevant elements should be adjusted correspondingly. Following the logic of the framework of Melville et al. (2004) and considering the supply chain feature, we generate an integrated framework to provide a blueprint for the studies on the impact of ICT on supply chains and SC performance. This framework is presented in Figure 1.2.

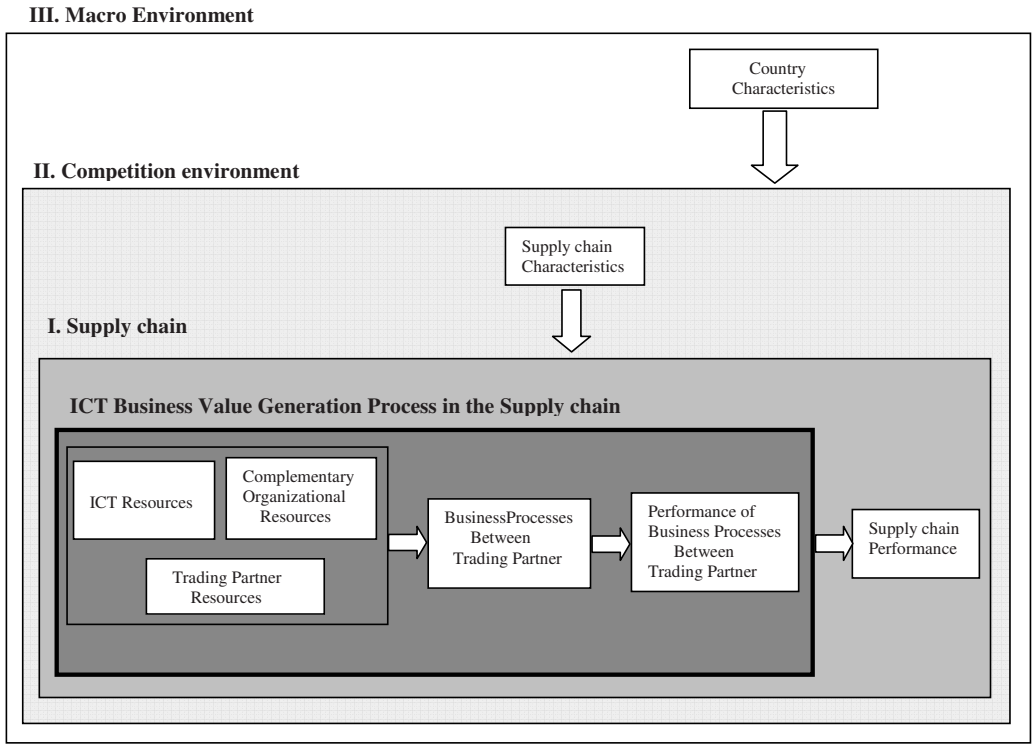

Figure 1.2 The impact of ICT on supply chain and supply chain performance

The integrative framework of ICT business value also comprises three domains: (1) supply chain; (2) competitive environment; and (3) macro environment. It describes how phenomena within each domain shape the relationship between ICT and SC performance. In the context of supply chains, the first domain is the supply chain replacing the focal firm in the original framework of Melville et al. (2004). That also means that the relevant business processes are not only the ones within a firm but also processes between trading partners. In other words, instead of only within-firm processes we now focus on supply chain processes within and between firms. In addition, a trading partner is regarded as a resource in the supply chain and not as a part/element of the external competitive environment. In this domain the application of ICT and complementary resources may improve supply chain processes or enable new ones, which ultimately may impact SC performance. The second domain in this framework is the competitive environment in which the supply chain operates. A supply chain can be global and composed of firms from different industries. Therefore, to discuss the influence of the environment, studies should focus on supply chain characteristics (such as the type of supply chain or the amount and type of uncertainty it experiences). Similar to the framework of Melville et al. (2004), the third and final layer in the integrative framework is the macro

environment, denoting country- and meta-country specific factors that shape ICT applications for the improvement of SC performance. Following the logic of Melville et al. (2004), the above integrative framework suggests that ICT business value is generated by the deployment of ICT and complementary resources within supply chain processes. In addition, the external factors also play a role in shaping the extent to which ICT business value can be generated and captured. In particular, supply chain characteristics, as well as the macro environment are salient to ICT business value generation.

1.2.3 Research questions

Based on the framework, we can identify five research questions corresponding to the three domains:

(1) Are ICT resources associated with improved supply chain performance?
(2) How do ICT resources generate improved supply chain performance?
(3) What is the role of complementary organizational resources and business processes of electronically linked trading partners in generating and capturing ICT value? (The first three questions are related to the domain supply chain.)
(4) What is the role of supply chain characteristics in shaping ICT business value? (related to the domain competitive environment)
(5) What is the role of country characteristics in shaping ICT business value in a supply chain? (related to the domain macro environment)

In the existing literature, most studies focus on the first domain of the framework and seem to neglect the influence of the supply chain environment (e.g. Jayaram et al., 2000; Frohlich and Westbrook, 2002). Within the research on the supply chain domain studies mainly examine the first research question that is whether ICT is associated with SC performance (e.g. Da Silveira and Cagliano, 2006; Saeed et al., 2005). The second and third question has received much less attention. Further, a majority of the existing studies refer to e-business, e-SCM (e-supply chain management), or e-integration and discuss the impact of these items on SC performance (e.g. Sanders, 2007; Power and Singh, 2007). These concepts focus on the supply chain activities enabled by internet, which means they measure the supply chain activities and the technology in one construct. Supply chain management and supply chain integration are multi-dimensional concepts which cover many business processes. We are usually told that e-SCM or e-integration is needed, however we know little about what business processes of supply chain management or supply chain integration are actually influenced by internet and how they interact to improve SC performance. In other words, these studies have not provided a clear description for the second and third question, which implies that many crucial details about how ICT influences SC performance are still unclear.

With respect to the fourth question, a few studies have done exploratory work but still do not provide sufficient answers (e.g. Kim and Narasimhan, 2002). Most studies extend the

scope of ICT business value generation without incorporating the role of the competitive environment in shaping ICT business value. Whereas studies frequently mention that ICT can help to create a seamless flow of goods and information, still it is not investigated what is needed to develop and implement appropriate ICT nor is studied if ICT is really capable of providing such seamless information flows. Sometimes it seems that pen-and-paper solutions, along with face-to-face communication, are still the most powerful approach. Maybe, we should even investigate whether we need the paradigm of seamless flow of information in all circumstances (Van Donk, 2008).

The fifth question is related to the remaining domain in the framework: macro environment. Because there is a lack of cross-country studies, we know very little about the association between macro characteristics and ICT business value. Although existing studies have examined firms in North American (e.g. Ward and Zhou, 2007), Brazil (e.g. Tigre and Botelho, 2001) and Taiwan (Tai et al., 2010), it is difficult to draw any conclusion with regard to the impact of macro factors as research designs do not incorporate the same factors. While exploring cross-country effects is certainly worthwhile, the present study is limited to one country (China). This means that we decided not to investigate the fifth question.

To summarize, the investigation of the relationship between ICT, supply chain management and SC performance is still in its early stages. Most existing studies have only explored the direct relationship between ICT and SC performance. However, the explanations for underlying mechanism are still lacking and the important questions are not fully understood yet. The absence of complete answers to the above research questions shows that we still know relatively little about the relationship between ICT and supply chain management. This thesis aims to answer the first four research questions and to reveal the mechanism under a unified theoretical framework using the data gathered from China. In the next section, we will introduce ICT development and ICT-related research in China

1.3 Chinese background

Although the informationization in China began later than in Europe or in the U.S., the speed of development is extremely high, especially during the past ten years. Government policymakers in China have acknowledged the importance of ICT to the country's economic and industrial development. Specifically, it was identified that development of the ICT industry as a top priority in the country's 10th five year national economic plan announced in 2001. For this plan, the government had invested $151 billion over a period of five years (2001–2005) to build a national telecommunications infrastructure. Further, in the 16th and 17th National People's Congress in 2002 and 2007, the government announced the strategies: "informationization and industrialization promote each other" and "integration ICT into industry" for the future. The statistics shows that the government's initiatives are working. According to the report of Ministry of Industry and Information Technology of the People's

Republic of China, the petroleum and chemical industry, steel industry, light industry and textile industry invested around € 280 billion in ICT during 2006-2010, which counts for 40% of the total investments within these industries.

Chinese manufacturing flourished because of the really cheap labor during the late 90s. Firms were more focused on getting orders and paid less attention to supply chain management. However, since 2001 when China joined the World Trade Organization, Chinese firms in the domestic market were likely to face intense competition from foreign rivals. It was crucial that they responded quickly to market demand and that they produced and delivered the goods to the customer on time. Meanwhile, more and more foreign rivals moved their factories to China. These factories also faced the problem how to build an efficient supply chain across geographical distances. The competition is supply chai to supply chain instead of company to company. Here again, ICT can be used by prospective executives to help manage their supply chain and gain competitive advantage**.** As ICT has been implemented in Chinese organizations, the debate around the creation of ICT business value is also inevitably relevant for China (Chau et al., 2005). By analyzing Chinese data this dissertation not only shows the status of ICT application in Chinese manufacturers which can be compared to the existing studies in Europe or U.S., but also reveals the underlying mechanisms with respect to how ICT influences supply chain management and SC performance in general.

1.4 Outline of the thesis

In recent years, there has been an increasing amount of research regarding the impact of ICT on supply chain management and SC performance. However, empirical evidence on this issue is still fragmented and a comprehensive conceptual framework to integrate different theoretical perspective is lacking in the literature (Jean et al., 2008). The framework presented in Section 2.2 provides us with an initial understanding for the studies on ICT business value for supply chains. However, it is too abstract to guide further study.

Therefore, in Chapter 2, based on this framework and following its logic we develop a more detailed framework to synthesize what is done and absent in the existing studies. We review and classify survey-based research connecting ICT, supply chain management, and SC performance from 1995 until 2010. Papers are selected from 15 major journals in the field of OM, MIS and logistics. By reviewing the measurement items, the variables, the relationship between variables and the corresponding frameworks, we summarize the possible sources for conflicting findings in the ICT-SC performance debate. Based on the analysis of the existing research, we aim to provide a blueprint to guide future research and facilitate knowledge accumulation and creation concerning the supply chain management and performance impacts of ICT. Chapter 2 is the guider and also the foundation of the dissertation.

The findings in Chapter 2 indicate that past studies discussed ICT in an aggregated and ambiguous way. Studies in the MIS field have indicated that the dimensions and extent of ICT business value depend on ICT types (Brynolgsson et al., 2002; Cooper et al., 2002). Especially in the context of supply chains, some types of ICT seem to be more closely connected with the business processes between partners (e.g. internet, EDI) while some other kinds of ICT (e.g. MRP/MRPII) are used to manage the process within the firms. Correspondingly, it should be detected how different types of ICT influence SC performance. In Chapter 3, we focus on the first domain - the supply chain domain - of the framework shown in Figure 1.2: the ICT business value generation process in the supply chain. We categorize ICT into inter-organizational ICT and intra-organizational ICT, and focus on two main aspects of supply chain integration: information sharing and cooperation. We investigate how inter- and intra-organizational ICT interact with these two integration aspects, and consequently contribute to SC performance. In this chapter, we aim to answer Question 1 and 2: what is the relationship between ICT and SC performance and how does ICT have an impact on supply chain management and SC performance. Meanwhile, we incorporate the perspective of supply chain management to categorize ICT into intra- and inter-organizational ICT. By answering the question whether different types of ICT have a different impact on SC performance, we aim to achieve a better understanding and enrich the knowledge of the underlying mechanism in how ICT improves supply chain management.

There seems to be consensus about ICT as an important tool to help manage supply chains and enhance SC performance. However, that does not automatically imply that more ICT is always beneficial for a supply chain. Important starting point of Chapter 4 is to challenge the idea of an unconditional positive impact of ICT on SC performance regardless of the supply chain environment. In this chapter, we examine the role of ICT on both domains 1 and 2 (Figure 1.2). In other words, we include both the supply chain domain and the competitive environment domain. We check if the supply chain environment influences the ICT business value generation process in supply chains. We focus on demand uncertainty, which is one of the key elements of the supply chain environment. By comparing the relationship between ICT, supply chain integration and SC performance under high and low demand uncertainty, we examine the moderating role of demand uncertainty. Most studies about the impact of ICT on supply chain have neglected the supply chain context, thus this chapter fills this gap and provides a comprehensive discussion. This chapter aims to answer under what situation ICT is needed, and further to make clear that a fit is needed between ICT application and the supply chain context.

In order to investigate these topics, we gathered data from 320 industrial suppliers in China. A description of the data collection method is included in each of the empirical chapters so that they can be read independently of each other.

Chapter 5 provides an overview of the main findings of this research, followed by a discussion of the theoretical and practical implications. Finally, the limitation of this study and possibilities for future research are discussed.

CHAPTER 2※

CAN ICT INFLUENCE SUPPLY CHAIN MANAGEMENT AND PERFORMANCE? A REVIEW OF SURVEY-BASED RESEARCH

2.1 Introduction and background

It is indisputable that ICT (information and communication technology) has an enormous effect on contemporary business. However, the relationship between ICT and supply chain (SC) performance is less straightforward. Some studies show that there is a positive relationship between them (e.g., Jayaram et al., 2000; Olson and Boyer, 2003), but other studies present less evidence (e.g. Narasimhan and Kim, 2001; Da Silveira and Cagliano, 2006) or do not even find a relationship (e.g. Jeffers et.al, 2008). In an attempt to better understand the relationship ICT-SC performance and the underlying mechanisms, researchers have investigated the indirect effect of ICT on SC performance through supply chain management (SCM). Again the results are mixed. A number of studies (e.g. Kent and Mentzer, 2003; Sanders and Premus, 2005) show that ICT positively affects SCM and improves SC performance. For example, ICT can strengthen buyer-supplier relationship through more efficient processes and can reduce lead time (e.g. Cagliano et al., 2003; Ward and Zhou, 2006). However, others (e.g. Sriram and Stump, 2004) found no obvious relationship between ICT and SC performance. We also noticed that different measurements and constructs where used to capture the central elements in the relationship. For example, some papers (e.g. Sanders and Premus, 2005; Zhang and Dhaliwai, 2009) measure ICT in rather aggregate terms, while others focus on specific technologies like EDI (e.g. Lai et al., 2008) or APS/ERP (e.g. Swafford et al., 2008). Similarly, it seems that SCM and SC performance are measured in different ways.

These contradictions in empirical findings and differences in measurements motivated us to start a systematic review and analysis of the research in this field. The main question to be addressed is if ICT has a positive effect on SC performance, either directly or indirectly through improved supply chain management. Firstly, we investigate what constructs and measurements for each of the central concepts – ICT, SCM and SC performance - are used in papers investigating the relationship between ICT, SCM and SC performance. Then, we address the questions which of the possible relationships have actually been taken into account in earlier research. Investigating these two questions, can help to find which aspects

※This chapter is based on Zhang, X., Van Donk, D.P. & Van der Vaart, T. (2011), "Does ICT influence supply chain management and performance? A review of survey-based research", International Journal of Operations & Production Management, 31(11), pp. 1215-1247.

of ICT have been investigated and which ones seem to be effective. Additionally, it will shed light on the actual mechanisms that help to use ICT in an effective way. It might be that differences in measurement and concept can account for different findings. It might as well be that findings, that seem to be similar, actually deal with different aspects of the relationship between ICT, SCM and SC performance. Finally, we will investigate whether the context of the supply chain (cf. Ho et al., 2002) plays an explicit role in different studies examining the relationships between ICT, SCM and performance and assess the role of context in explaining different results, To answer that question we investigate systematically if contextual factors are investigated, which contextual factors are used and what their effect is.

In short, the aim of this paper is to systematically review and analyze those survey studies that have reported on the relationship between ICT, SCM, and SC performance, in order to detect possible sources for similarities and differences in reported findings. We restrict the review to survey-based research, as that research methodology is generally accepted as being specifically suitable for theory testing.

The paper is organized as follows. The next section will discuss the central concepts and present the research framework. Then, we describe our methodology, explaining how we selected the papers for the review. The fourth section presents an analysis of the measurements of the three main concepts: ICT, SCM and SC performance used in the reviewed papers. In section five, we explore different types of relationships found in the selected papers. The sixth section will analyse and discuss the findings. In the final section, we will present the main conclusions and directions for future research.

2.2 Central concepts and research model

As explained in the introduction our main point of interest is to explore the effect of ICT on SC performance. As said, different, opposing results have been reported in the literature. In an attempt to better understand these results and thus how ICT can improve SC performance, research has incorporated different aspects of SCM. Incorporating SCM helps to understand through which mechanisms SC performance improvements can be reached. So far, the literature does not offer a unified theoretical framework. Different theoretical lenses have been applied, resulting in different basic mechanism and choices for particular aspects of SCM. Some authors (e.g. Ray et al., 2004, Jeffers et al., 2008) start from a process-oriented view of value creation. That perspective results in models, where SCM mediates the effect of ICT on SC performance. Another theoretical point of departure is the resource-based view (RBV) of the firm (Barney, 1986, 1991) resulting in the idea that ICT is a firm's resource. Performance improvement in that theoretical perspective stems from the interaction between ICT and SCM. In other words, SCM is modeled as a moderator of the relationship ICT and SC performance. A final line of thinking is closely related to contingency theory (e.g. Thompson, 1967; Mintzberg, 1979). This view follows the central idea of the contingency

theory that the effectiveness of certain practices, such as the use of ICT and SCM, might depend on environmental characteristics (Flynn et al., 2010) as organizational size or uncertainty in demand. The above short sketch of the theoretical background of recent work in our area of interest leads to the need to define the central concepts of our study: ICT, SCM, SC performance and context. We have chosen for generally accepted definitions and descriptions of these concepts, which also reflect the broad scope of the research. Next, we will explicitly address the different models that result from the different theoretical perspectives in the literature, which are used to classify the literature.

Information and Communication Technology (ICT) can be defined as a family of technologies used to process, store and disseminate information, facilitating the performance of information-related human activities, provided by, and serving both the public at-large as well as the institutional and business sectors (Salomon and Cohen, 1999). In this paper we also incorporate investment in ICT and relevant infrastructures. This rather broad definition enables to distinguish between different types of ICT and at the same time incorporate all different types and approaches that are grouped under this description. In addition, it seems that a number of the relevant papers use a rather broad definition of ICT, as well.

Supply Chain Management (SCM) has numerous definitions, usually with a similar underlying theme of integrating the firm's internal processes with suppliers, distributors, and customers (Tan et al., 1998, Tan et al., 1999; Elmuti, 2002). An often cited definition comes from the Council of Logistics Management (2000): SCM is the systemic, strategic coordination of the traditional business functions and tactics across these businesses functions within a particular organization and across businesses within the supply chain for the purposes of improving the long-term performance of the individual organizations and the supply chain as a whole. Again, this is a well-accepted definition that incorporates many different SCM aspects.

Supply chain performance (SC performance) is usually defined in terms of reliability, responsiveness, flexibility, cost, and asset management efficiency (e.g. Supply Chain Council, 2003). A closely related definition is the one given by Slack et al. (2007) which is related to the general accepted performance measures in operations management: cost, speed, dependability, quality, and flexibility. Following a recent review of surveys of SCM-research (Van der Vaart and Van Donk, 2008), we also consider more general – less operational - measurements reflecting the effectiveness or efficiency of the activities of a supply chain, such as turnover, market share and financial performance as indicators of SC performance.

With respect to the contextual factors, we follow Ho et al. (2002) who define context as the setting in which organizational practices are established and applied. Consequently, c*ontextual factors* can be defined as the main factors that determine and characterize the organizational setting. Relevant factors for supply chain management are for example the

complexity of the supply chain, the position in the chain, and technological and demand uncertainty.

Figure 2.1 presents the major relationships between ICT, SCM and SC performance, resulting from the literature as described above. The first model assumes that ICT will have a direct impact on SC performance. Argument for this the relationship is that the use of ICT (in any form) is directly improving SC performance through e.g. better information availability, accuracy or through direct computer-to-computer links. In the second model the relationship between ICT and SC performance is assumed to be mediated by SCM. An example might be that the use of a specific computer-to-computer linkage will improve information sharing and/or cooperation (as parts of SCM). Increased information sharing and/or collaboration in turn will improve SC performance. The third model assumes that the relationship between ICT and SC performance is moderated by SCM. The line of reasoning is that ICT becomes effective under a certain condition: a high level of SCM, while ICT might have limited or no effect if SCM is low. Finally, the fourth model relates to research that investigates the link ICT-SCM. Such research might be done in the context of a mediation model or the research has the implicit assumption that improvements in SCM will automatically lead to an improved SC performance. We refer to the literature for further explanation and motivation for the hypotheses underlying each of the four models.

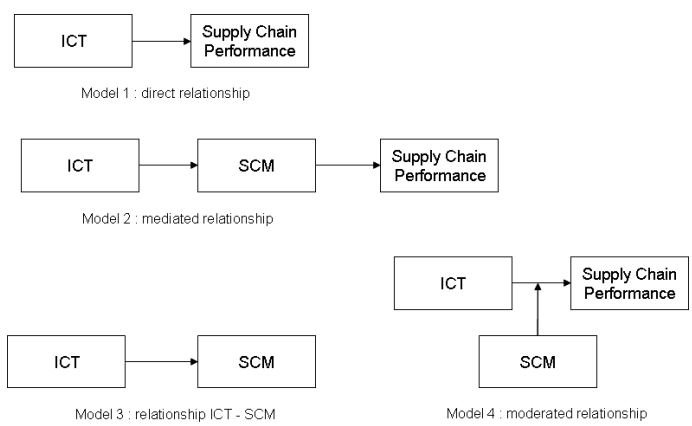

Figure 2.1: Models about the relationships between ICT, SCM and SC performance

In addition to the above elaborated relationships between the three key concepts SCM, ICT and performance, we will also classify and investigate the effect of contextual factors. A variety of factors have been considered as contextual factors such as firm size and competitive environment. The expectation is that such factors might positively or negatively affect relationships. An example might be that only in large firms ICT will have a positive impact on performance.

2.3 Methodology: journal and paper selection

This paper aims to review survey based research on supply chain management and ICT. In order to do so, we collected papers from journals in three research areas: Operations Management, Information System, and Logistics. In this study we aim to review papers from journals that are generally accepted as the journals having the highest standard and quality in their respective fields. Indicators for quality are impact factors, perceived quality and impact by professionals, and selection of journals in earlier review papers. Applying these criteria on each of the three areas, resulted in the selection process outlined below.

The Operations Management journals have been based on previous studies that classified and ranked the most significant journals within this field (e.g. Vokurka, 1996; Goh et al., 1996; Soteriou et al., 1999; Donohue and Fox, 2000; Barman et al., 2001; Vastag and Montabon, 2002). As a consequence seven Operations Management journals were selected (see Table 2.1).

Information System journals have been selected by considering both the journal ranking and impact factors (Whitman et al., 1999; Mylonopoulos and Theoharakis, 2001; Peffers and Tang, 2003; Lowry et al., 2004; Rainer and Miller, 2005). We excluded pure computer science journals and focused on those journals that focus on management issues. As a result we included four Information System journals (see Table 2.1).

Logistics journals have been chosen by analyzing journal assessments (see OM references mentioned above) and by examining review papers in the field of supply chain management (Croom et al., 2000; Gunasekaran and Ngai, 2005; Gibson and Hanna, 2003; Zsidisin et al., 2007; Van der Vaart and Van Donk, 2008). We ended up with four logistics related journals (see Table 2.1).

Paper selection

(1) We focused our investigation on the period 1995-2008, as Alfaro et al. (2002) indicated that only 2 percent of published papers in 1995 were addressing SCM. Consequently, research in our topic area has been even more limited before 1995. Due to the existence of multiple key words related to the topic, we choose several sets of search words in order to find relevant papers. We are mainly interested in three factors: SC performance, supply chain management, information and communication technologies. We choose “supply chain” to represent the two SC factors and “information”, “communication”, “e”, and “ICT” to represent the ICT factor. Furthermore, because some authors discuss specific types of ICT, we also choose internet, EDI, and ERP as search word. We use the fixed word “supply chain” and the floating words “information”, “communication”, “e”, “ICT”, “ERP”,”EDI”, “internet” to search in the titles, abstracts and the keywords in the electronic journal database chosen.

(2) In order to further select appropriate papers the following further criteria were used:

- Survey is the main methodology used in the paper.
- The backbone of our research is ICT. The papers that discuss the relationship either between ICT and SCM or ICT and SC performance will be included, contrarily, the papers that only discuss the relationship between SCM (e.g. information sharing) and performance will not be included for further examination.
- The research is restricted to *SC performance*. We selected papers using those items that are typically used in the evaluation of SC performance, such as inventory cost and delivery speed. Some papers measure performance using purely financial measures such as ROA and ROS which are not directly related to SC performance. We decided not to include these papers because they do not match our interest in the impact of ICT on SC performance.

(3)Based on the above criteria, we initially selected a set of 49 papers. In the further selection process, abstracts were assessed to find out whether these papers really fitted with our research objectives as outlined above. The remaining papers were examined in detail. Independent from each other, all three authors drew up a summary of all papers in terms of the relevant factors (SCM, ICT, performance, and context), the items considered, the sample, and the industries in order to make an adequate comparison of the papers possible. Results of the different authors were then combined, and in the event of significant differences discussed until an agreed summary was established.

In this stage of the selection process, we excluded a number of papers for different reasons: upon further consideration the research did not address SC performance (Byrd and Davidson, 2003; Dadzie et al., 2005; Johnson et al., 2007); the paper did not investigate ICT (Hendricks and Singhal, 2003; Kulp et al., 2004; Gattiker et al., 2007; Krause et al., 2007; Rabinovich, 2007); the paper was investigating antecedents of global operations strategy (Prater and Ghosh, 2006); the research was not survey-based (Walton and Gupta, 1999; Sawy et al., 1999; Croom, 2001; Raghunathan and Yeh, 2001; Fan et al., 2003; Graham et al., 2004; Mclvor and Humphreys, 2004; Croom, 2005; Dehning et al., 2007) or the paper aimed at construct development only (Chen and Paulraj, 2004). Cagliano et al. (2005) was excluded because this paper seeked to review the results of a paper originally published in 2003 (Cagliano et al., 2003).

As a result we ended up with 29 papers for the final analysis (see Table 2.1). As can be seen in Table 2.1, Journal of Operations Management is the journal with the highest number of papers that fit with the criteria. More generally, the Operation Management journals have more published papers fitting our aim than the Logistics journals and Information System journals. Note that there are only three papers from Information System journals. Empirical

work seems to be limited in the information system field, maybe because the research is more focused on the development and application of information related technologies.

Table 2.1 Overview of journals and papers selected

Journals (15)	Number of papers (29)
Management Science	0
Journal of Operation Management	9
Decision Science	3
International Journal of Operation & Production Management	3
Production and Operation Management	0
The International Journal of Production Research	1
The International Journal of Production Economics	3
MIS Quarterly	2
Information System Research	0
Journal of Management Information Systems	0
Information & Management	1
Journal of Business Logistics	4
International Journal of Physical Distribution and Logistics Management	2
Journal of Logistics Management	0
Journal of supply chain management	1

2.4 Factors, constructs and items: measuring the key variables

In this section, we focus on the factors, constructs and items used to measure ICT, SCM and SC performance.

2.4.1 ICT

Table 2.2 summarizes how ICT is measured within the selected papers. We analyze the papers according to two main criteria: the ICT stage and the types of inter-organizational or intra-organizational ICT employment.

With respect to the first criterion, we distinguish three subsequent stages in the employment of ICT: ICT investment, ICT usage and ICT capability. That distinction is inspired by the resource-based view on organizations (see Barney 1986, 1991), which is often used to investigate the link between organizational performance and resources or technologies (e.g. Clemons and Row 1991; Mata et al., 1995; Bharadwaj, 2000). The other criterion is used to discuss the papers in terms of the type of technology used like EDI and ERP. It is important to note that some papers (e.g. Devaraj et al., 2007; Sanders and Premus, 2002) incorporate concepts like VMI and CPFR in their measurement of ICT. We tend to agree with Disney et al. (2004) that these concepts are essentially supply chain strategies. Therefore, we choose not to incorporate them in Table 2.2.

As Table 2.2 shows, most papers measure ICT usage, only seven papers measure ICT capability and two papers ICT investment. The distinctions between these three stages and

their possible impact on the management and performance of the supply chain have not been considered explicitly. We will explore this further in the discussion section of this paper.

Next to differences in measuring the stage of ICT, Table 2.2 also shows that a large number of different technologies have been used to measure ICT. Some papers (e.g. Subramani, 2004; Sanders and Premus, 2005) measure ICT as a general concept. On the contrary, other papers (e.g. Sanders, 2007, Olson and Boyer, 2003) measure ICT in a rather limited way: one specific type of technology. In fact, only a limited number of papers use a broad range of technologies (e.g. Paulraj and Chen, 2007b; Sanders and Premus, 2002). Another remarkable finding is that EDI, although being a relatively established – almost traditional - technology is used very frequently, even more frequently than Internet, or web-based technologies. Within the group of Intra-organisational technologies the ERP/MRPII and automatic data systems and other tracing technologies are most frequently used in the surveys.

A second observation is that the majority of the research focuses on the Inter-organizational Information System type of technologies and far less on the Intra-organizational systems such as ERP. That focus is to some extent logical, as Inter-Organizational Information Systems are naturally related to SCM which is also supposed to be crossing the borders of the organisation.

2.4.2 Supply chain management

Given that earlier research has shown confusion in the definition and measurement of SCM (e.g. Chen and Paulraj, 2004), we will now consider in more depth the actual supply chain management factors and items used in the selected papers.

Table 2.3 lists the SCM factors mentioned in the sample. The philosophy of supply chain management is founded on collaboration among supply chain partners (e.g. Andraski, 1998; Stank et al., 2001). This is clearly reflected in the names given to the factors, as integration and coordination dominate. However, different types of integration are distinguished. The majority of authors take external collaboration into account, only a few authors (e.g. Sanders and Premus, 2005; Sanders, 2007) also consider internal collaboration.

Table 2.2 Measures and characteristics of ICT[1]

Paper	Stage	Inter-organizational Technologies						Intra-organizational technologies				
		Internet, Web-based	Extranet	E-Business	E-mail, Fax	EDI	XML	ADCS, TEDS	Electronic boards	APS	SFM	ERP, MRP-II
Cagliano et al. (2003)	U	X										
Cagliano et al. (2006)	U											X
Da Silveira and Cagliano (2006)	U	X	X	X		X						
Devaraj et al. (2007)	U/C	X				X				X		
Frohlich and Westbrook (2002)	I/U	X										
Hill and Scudder (2002)	U					X						
Hsu et al. (2008)	U					X						
Jayaram et al. (2000)	U					X		X		X	X	X
Jeffers et al. (2008)	U	X				X		X		X		X
Kent and Mentzer (2003)	U/C					X		X				
Kim and Narasimhan (2002)	U		IT measured in aggregated terms						IT measured in aggregated terms			
Lai et al. (2008)	U					X						
Li et al. (2009)	U					X		X				X
Narasimhan and Kim (2001)	U		IT measured in aggregated terms						IT measured in aggregated terms			
Olson and Boyer (2003)	C	X										
Paulraj and Chen (2007b)	U	X	X		X	X		X				
Paulraj et al. (2008)	U	X	X		X	X		X				
Power and Singh(2007)	U			X			X					
Rai et al. (2006)	C							X		X		X
Saeed et al. (2005)	U	X	X			X						
Sanders (2007)	U/C			X								
Sanders(2008)	U											
Sanders and Premus (2002)	U	X						X	X			X
Sanders and Premus (2005)	C		IT measured in aggregated terms						IT measured in aggregated terms			
Subramani (2004)	U		IT measured in aggregated terms						IT measured in aggregated terms			

[1] I=investment; U=usage, C=capability; ADCS=automatic data capture system; SFM=system for manufacture (including CAD/CAM and CIM), TEDS = Tracing and/or expedite delivery system.

Swafford et al. (2008)	U	IT measured in aggregated terms			IT measured in aggregated terms except APS/ERP			
Vickery et al. (2003)	U		X			X		
Ward and Zhou (2006)	I				X	X	X	
Zhang and Dhaliwai (2009)	U/C	IT measured in aggregated terms			IT measured in aggregated terms			

Table 2.3 Factors and items used to measure supply chain management

Paper	SCM factor	Items		
		Practices	Patterns	Attitudes
Cagliano et al. (2003)	Information sharing	X		
	System coupling	X		
Cagliano et al. (2006)	Information sharing	X		
	Redesign and system coupling	X		
Da Silveira and Cagliano (2006)	-			
Devaraj et al. (2007)	Supplier/Customer production information integration	X		
Frohlich and Westbrook (2002)	Supply integration	X		
	Demand integration	X		
Hill and Scudder (2002)	Customer coordination	X		X
	Supplier coordination	X		X
Hsu et al. (2008)	Supply chain architecture	X	X	X
	Relationship architecture	X		X
Jayaram et al. (2000)	-			
Jeffers et al. (2008)	-			
Kent and Mentzer (2003)	Relationship commitment			X
Kim and Narasimhan (2002)	Stages of integration	X		
Lai et al. (2008)	-			
Li et al. (2009)	Supply chain integration	X		
Narasimhan and Kim (2001)	-			
Olson and Boyer (2003)	-			
Paulraj and Chen (2007b)	External logistic integration	X		
	Strategic buyer-supplier relationships			X
Paulraj et al. (2008)	Inter-organizational communication	X	X	
Power and Singh (2007)	Trading partner relationships	X		
Rai et al. (2006)	Information flow integration	X		
	Physical flow integration	X		
	Financial flow integration	X		
Saeed et al. (2005)	-			
Sanders (2007)	Inter-organization coordination	X		
	Intra-organization coordination	X		
Sanders(2008)	Operational coordination	X		

	Strategic coordination	X		
Sanders and Premus (2002)	-			
Sanders and Premus (2005)	Internal coordination	X		
	External collaboration	X		
Subramani (2004)	Business-process specificity	X		
	Domain-knowledge specificity	X		
Swafford et al. (2008)	-			
Vickery et al. (2003)	Supply chain integration	X	X	X
Ward and Zhou (2006)	Lean/JIT practices	X		
Zhang and Dhaliwai (2009)	-			

To further assess how SCM factors have been measured, we classified the items underlying the constructs. In line with Van der Vaart and Van Donk (2008), three types of items are distinguished: (1) Supply chain practices described as tangible activities or technologies that play an important role in the collaboration of a focal firm with its suppliers and/or customers; (2) Supply chain patterns, described as modes of interaction between the focal firm and its suppliers and/or customers, and (3) Supply chain attitudes, described as attitudes of buyers and/or suppliers towards each other or towards supply chain management in general (Van der Vaart and Van Donk, 2008, p.47).

As shown in Table 2.3, most factors are based on tangible activities. Remarkable is that even if the SCM factors used seem closely related, the actual measurement differs: Hill and Scudder (2002) use both practices and attitudes to measure coordination whereas Sanders (2007) only uses practices. Another example is the measurement of relationships: Paulraj and Chen (2007b) use practices and Power and Singh (2007) use attitudes. In general, a great variety of constructs is reported, and similar constructs are often measured in different ways and/or using different items. That finding is in line with results reported in Van der Vaart and Van Donk (2008).

2.4.3 Supply chain performance

Table 2.4 lists an overview of the performance measures used in the papers considered in this review. It is apparent from the second column of Table 2.4 that, again, a variety of labels is used. To really understand what has been measured in the papers a detailed analysis of the survey questions is conducted. We grouped the performance measures into eight basic measures. Four of these are closely related to what are considered to be the basic measures of operational performance (e.g. Slack et al., 2007): cost, delivery (speed and dependability), quality, and flexibility. Based on the review two performance measures are added: inventory and process improvement. Two other, more strategic, measures are distinguished: innovation measures and sales and financial measures. The financial and sales measures have been used extensively in earlier SCM and supply chain integration research. For a discussion of the value of using aggregate or specific operational measures, we refer to Van der Vaart and Van Donk (2008).

If we consider Table 2.4, two issues emerge. A variety of differently labelled constructs is used whereas the underlying items mostly refer to the same basic operational performance measures. Second point is that some constructs use both operational and strategic measures (e.g. Swafford et al., 2008, Subramani, 2004) which might raise doubts about the face validity of the constructs.

2.4.4 Contextual factors

A number of authors has noticed that context of the supply chain (Ho et al., 2002) might influence the relationships between ICT, SCM, and SC performance. Different aspects have been proposed to investigate the influence of those factors, such as type of product (Fisher, 1997; Ramdas and Spekman, 2000), replaceability (Subramani, 2004), or demand variability (Germain et al., 2008). In the perspective of this paper, we list all variables that are taken into account in the papers we consider. A first observation is that within the selected papers about a third does not consider any variable as a context or control variable.

Table 2.5 list two groups of contextual factors: firm characteristics and supply chain characteristics. Firm characteristics reflect the internal features of a company while supply chain characteristics describe influencing factors and/or characteristics of the supply chain or supply chain relationship. Here again, the difficulty with the factors is that different authors use various items and constructs to measure the same or closely related factors. Although it is well accepted, three papers (Hill and Scudder, 2002; Subramani, 2004; Da Silveira and Caglliano, 2006) all examine firm size, but in a different way: Subramani uses annual sales revenues; Da Silveira and Caglliano use the number of employees; Hill and Scudder use both. Another example, probably with more consequences, relates to industry. Devaraj et al. (2007) and Cagliano et al. (2006) gathered data in different types of industry. The former paper uses data from two different industries: automotive and computers/electronics industries, while the latter one distinguishes eight different types of industry (based on ISIC codes).

Table 2.4 Performance constructs and items used

Paper	Construct								
		cost	delivery	quality	flexibility	inventory	process improvement	innovation	sales and financial
Cagliano et al. (2003)	-								
Caglinao et al. (2006)	-								
Da Silveira and Cagliano (2006)	Cost	X				X			
	Delivery		X						
	Flexibility				X				
	Quality			X					
Devaraj et al. (2007)	Operational performance	X	X	X	X	X			
Frohlich and Westbrook (2002)	Operation performance	X	X			X			X
Hill and Scudder (2002)	-								
Hsu et al. (2008)	Market Performance		X	X	X				X
Jayaram et al. (2000)	Time-based performance		X		X			X	
Jeffers et al. (2008)	Customer-service process performance		X	X					
Kent and Mentzer (2003)	Logistics efficiency	X							
	Logistics effectiveness		X						
Kim and Narasimhan (2002), Narasimhan and Kim (2001)	Differentation		X	X	X		X	X	
	Cost reduction	X							
Lai et al. (2008)	Logistics cost performance	X							X
	Logistics service performance		X	X					
Li et al. (2009)	Supply chain performance	X	X	X		X			
Olson and Boyer (2003)	Organization performance	X	X				X		
Paulraj and Chen (2007b)	Agility performance (of supplier and buyers)		X	X	X				
Paulraj et al. (2008)	Supplier performance	X	X	X	X				
	Buyer performance	X	X	X	X				
Power and Singh (2007)	-								
Rai et al. (2006)	Operational excellence		X				X		
	Customer relationship								
	Revenue growth								X
Saeed et al. (2005)	Process efficiency	X	X						
	Sourcing Leverage	X			X			X	

Sanders (2007)	Organizational performance	X	X	X				X	
Sanders (2008)	Operational benefits	X					X		X
	Strategic benefits							X	
Sanders and Premus (2002)	Operations performance	X	X	X					
	Strategic Performance							X	
Sanders and Premus (2005)	Firm performance	X	X	X				X	
Subramani (2004)	Competitive performance								X
	Operational Benefits	X					X		X
	Strategic Benefits							X	
Swafford et al. (2008)	Supply chain flexibility		X		X				
	Supply chain agility		X		X			X	
Vickery et al. (2003)	Customer Service performance		X		X				
Ward and Zhou (2006)	Lead time		X						
Zhang and Dhaliwai (2009)	Technology-enabled operation improvement	X	X	X		X			
	Customer-service process performance		X	X					

Table 2.5 Contextual factors

Article	Contextual Factors		Models of contextual factors		
	SC characteristic	*Firm characteristic*	*Context as control variable*	*Context as variable*	*Context as moderator*
Cagliano et al. (2003)	Industry	Size; Position in the supply chain	.	ICT: partly	
Cagliano et al. (2006)	Complexity of the supply network; Structural changes;	Size; Position in the supply chain; Vertical integration	SCM: Y		
Da Silveira and Cagliano (2006)	level of outsourcing	Size; Process equipment investment; Position in the supply chain	P: N		
Devaraj et al. (2007)		Size; industry	P: N		
Frohlich and Westbrook (2002)					
Hill and Scudder(2002)	Product characteristics and Market type	Size		ICT: partly	
Hsu et al. (2008)		Region	SCM:N		SCM-P: Y
Jayaram et al. (2000)					
Jeffers et al. (2008)		Firm Size	P: N		
Kent and Mentzer (2003)					
Kim and Narasimhan (2002)					
Lai et al. (2008)					
Li et al. (2009)					
Narasimhan and Kim (2001)					
Olson and Boyer (2003)		Education; Annual training; Tenure in workforce		ICT: N	
Paulraj and Chen (2007b)					
Paulraj et al. (2008)					
Power and Singh (2007)					
Rai et al. (2006)	Consumer demand predictability;	Size	P: N		

Saeed et al. (2005)	Competitive intensity ; Internal integration	Product characteristics	P: Y		ICT-P: Y
Sanders (2007)					
Sanders (2008)					
Sanders and Premus (2002)	Competitive priorities			ICT: Y	
Sanders and Premus (2005)					
Subramani (2004)	Replaceability; Uncertainty	Size; Years of association Retailer	P: N		
Swafford et al. (2008)					
Vickery et al. (2003)					
Ward and Zhou (2006)					
Zhang and Dhaliwai (2009)					

P= SC performance; Y= existing influence; N= no influence; ICT-P= The relationship between ICT and SC performance; ICT-SCM= the relationship between ICT and SCM;

Apart from looking at different contextual factors, one can also look at how contextual factors are incorporated in the research and research models. In the set of papers, three ways are employed: (1) contextual factors are used as control variables; (2) contextual factors are assumed to have influence on the three key variables ICT, SCM and SC performance; (3) contextual factors are considered to moderate the relationship between ICT and SC performance. The first group is specifically aiming at improving the reliability of the models. It is assumed that these control variables do not have an influence. In the other two approaches contextual factors are incorporated in the models, either by assuming a direct influence on one of the variables or by assuming a moderating effect on the relationships between the variables. In most papers there is no significant impact of the control variables. Only Cagliano et al. (2006) find a significant effect of control variables on supply chain management.

The second group contains four papers that assume a relationship between contextual factors and ICT. Table 2.5 (fifth column) shows that the results are rather mixed. The last group contains three papers, that all confirm the influence of contextual factors on the relationship of SCM or ICT with performance.

The overall conclusion with respect to measurement seems that measurement of the core concepts differs across the various papers. The next question is of course whether and how the differences affect the main relationships as depicted in Figure 2.1.

2.5 Core findings: the effects of ICT

Following the models presented in Figure 2.1, four different types of relationship can be detected in the articles considered in this paper. a direct relationship between ICT and SC performance, a relationship ICT-SC performance mediated by SCM, a relationship ICT-SCM and a relationship moderated by SCM. Table 2.6 shows the distribution of the papers over these different relationships.

Table 2.6 Distribution of papers over types of relationships

Relationship	ICT - SC performance		ICT - (SCM) - SC performance		ICT - SCM	
	(Partly) confirmed	**Not confirmed**	**Mediated**	**Moderated**	**(Partly) confirmed**	**Not confirmed**
Paper	Da Silveira and Cagliano (2006); Jayaram et al. (2000); Kim and Narasimhan (2002); Lai et al. (2008); Narasimhan and Kim (2001); Olson and Boyer (2003); Saeed et al. (2005); Sanders (2007); Sanders and Premus (2002);Sanders and Premus (2005); Swafford et al. (2008); Zhang and Dhaliwai (2009)	Jeffers et al. (2008)[2]; Li et al. (2009); Ward and Zhou (2006)	Devaraj et al. (2007); Frohlich and Westbrook (2002); Hsu et al. (2008); Kent and Mentzer (2003); Li et al. (2009); Paulraj et al. (2008); Paulraj and Chen (2007b); Rai et al. (2006); Sanders (2007); Sanders(2008); Sanders and Premus (2005); Subramani (2004); Vickery et al. (2003); Ward and Zhou (2006)	Jeffers et al. (2008); Kim and Narasimhan (2002)	Cagliano et.al. (2003); Devaraj et al. (2007); Hill and Scudder (2002); Hsu et al. (2008); Kent and Mentzer (2003); Li et al. (2009); Paulraj and Chen (2007); Paulraj et al. (2008); Power and Singh (2007); Sanders (2008); Sanders and Premus (2005); Subramani (2004); Vickery et al. (2003)	Cagliano et al. (2006); Devaraj et al, (2007); Zhang and Dhaliwai (2009)

[2] Jeffers et al. (2008) confirms that there is no direct relationship between ICT and performance.

ICT-supply chain performance

The majority of the papers show that ICT at least has some effect on SC performance. Three papers do not support the positive effect: Jeffers et al. (2008), Li et al. (2009) and Ward and Zhou (2006). Additionally, Sanders and Premus (2002) find that ICT usage directly influences operational performance, but does not influence strategic performance.

ICT-supply chain performance via SCM

All papers listed in this group find a positive influence from ICT via SCM to SC performance, but different models and approaches are followed. A first remark is that some papers (such as Frohlich and Westbrook, 2002; Rai et al., 2006; Sanders, 2007) do not differentiate explicitly between SCM and ICT. They incorporate explicit ICT elements in their SCM-variables and assess the joint effect of SCM and ICT as one factor instead of two separate factors. We have chosen to classify these papers as mediating. A second remark is that several papers (e.g. Sanders and Premus, 2005; Sanders, 2007) combine some of the basic models of Figure 2.1 into their research model. They investigate both a direct effect of ICT and a mediating effect of SCM on SC performance. As a consequence, they are listed in both groups. Only two papers (Kim and Narasimhan, 2002; Jeffers et al., 2008) explicitly investigate the moderating effect of SCM on the ICT-performance relationship.

ICT-SCM

The final group in Table 2.6 lists the papers that investigate a relationship between ICT and SCM. Within this group some papers exclusively search for the relationship between ICT and SCM (e.g. Cagliano et al., 2003; 2006) while others investigate this relationship in the context of the ICT-supply chain relationship via SCM (e.g. Paulraj and Chen, 2007b). Again, most papers find a relationship. Only three papers do not find a relationship: Cagliano et al. (2006), Devaraj et al. (2007), and Zhang and Dhaliwai (2009).

Considering the above, there seems evidence to assume that our research model can be considered as a representation of proven findings. That is partly a surprise, as we intended it to be a means to classify rather than to represent research or reality. Firstly, it is remarkable that almost all research so far has only investigated direct and mediated relationships, while ignoring mostly the joint or complementary effect of ICT and SCM. With respect to this joint effect we only found Kim and Narasimhan (2002) and Jeffers et al. (2008) in our search. Secondly, to some extent the empirical findings are less confusing and contradicting than we

originally expected. However, as indicated in section 2.4, many different variables and measurements have been employed representing the key variables ICT, SCM and SC performance. Surprisingly, our review seems to indicate that a positive effect on performance can be expected, irrespective of what type of ICT and aspect of SCM is used and irrespective of the performance measure considered. The next section will further analyse and discuss if we can indeed draw such a general conclusion, or that a more nuanced view is required.

2.6 Analysis and discussion

The central theme of this paper is to systematically review and analyze survey studies that have reported on the relationship between ICT, SCM, and SC performance, in order to detect possible sources for similarities and differences in reported findings. As concluded above most studies show that ICT has a positive effect on SC performance either directly or indirectly via SCM. At the same time the reviewed papers do not help us to derive a comprehensive view on why and how ICT attributes to SC performance. Therefore, below the findings are explored to detect what is actually measured, to investigate differences in measures, and the possible effect thereof. These analyses are the basis for finding directions and guidelines for future research. Below we further discuss the measurements, followed by the analysis of the relationships.

2.6.1 Measurement of variables

With respect to measurement of variables, we distinguish two main issues. The first one relates to the conceptualizing and measurement of the key variables. The second one relates to the relative disregard of contextual factors.

Concepts and measurements

It should be realised that survey research has certain limitations above all. Most of the studies rely on single respondent, self-reported performance results and cross-sectional data. It is clear that survey research has certain disadvantages, and such disadvantages and possible pitfalls have been discussed in the literature (e.g. Meredith, 1998; Karlsson, 2009). While keeping this in mind, two main problems can be detected with respect to concepts and measurements.

Firstly, the key variables (ICT, SCM and SC performance) have been conceptualized differently and, as a consequence have been measured differently. Also, it appears that, as

indicated in earlier papers on supply chain integration (Chen and Paulraj, 2004; Van der Vaart and Van Donk, 2008), similarly labelled constructs are measured differently. We found differences in ICT measurement with respect to stage and type of technology. With respect to SCM we found that different concepts were used (e.g. internal or external collaboration) and that similar constructs were measured with different kind of items (practices, patterns and attitudes). Finally, SC performance is measured at different levels: operational and strategic. One would expect an effect of such a diversity of measures, but somehow the majority of the research does find an effect of ICT. Probably, using relatively broad measurements helps to detect an effect. However, it does not help to detect which type of ICT or what type of SCM or which combination of the two, is most likely to improve a specific aspect of SC performance.

Secondly, measurements of key concepts have been limited, ignoring the breadth and complexity of the three key variables, without always being explicit in how the measurement (and thus the concept) has been delimited. Chen and Paulraj (2004) discussed previous research into measuring SCM and found fifteen different constructs related to supply chain management in their review of SC research. Van der Vaart and Van Donk (2008) found already more than thirty constructs. However, most of the selected papers incorporate only a few of these constructs or just one. Similarly, a large amount of different technologies can be used and is used, but most researchers opt for a limited number in their inquiries. Specifically in the context of ICT and SCM this seems risky as many alternatives exist (e.g. between usage of ICT and face-to-face communication or choice for a particular type of ICT) and interactions between ICT and SCM factors are complex. This last point is illustrated by Sanders and Premus (2005) and Sanders (2007) who show that the relationship between external collaboration and firm performance is indirect through internal collaboration. They support the argument of Subramani (2004) that internal collaboration constrains the benefits of external collaboration. Therefore, we conclude that excluding internal collaboration, but also excluding internal oriented ICT as ERP-systems, as is often done, might exclude relevant factors in the complex real-life interactions between various concepts. Similarly, the focus on inter-organizational information systems, possibly neglects interaction between different types of ICT, aspects of SCM and SC performance. In addition, based on the research reviewed in this paper, it is hard to detect how individual technologies contribute to - aspects of - SCM and to specific performance elements. In addition, it is also hard to trace the relationships between individual technologies and if and how individual technologies interact with different aspects of SCM or might substitute aspects of SCM.

Contextual factors

Although the literature suggests that contextual factors influence SCM and ICT and therefore also the relationships between SCM, ICT and SC performance, only a few papers have incorporated these factors. Some of the contradictory results can clearly be associated with the disregard of context as is indicated by the effects of contextual factors in a few studies.

The main source for the argument that contextual factors are important, is Fisher (1997) who has been followed by a limited number of empirical studies (e.g. Darr and Talmud, 2003; Lamming et al., 2000; Ramdas and Spekman, 2000). In addition some recent empirical work has been done in the context of supply chain management without considering ICT (Germain et al., 2008; Bozarth et al., 2009). Fisher distinguishes between innovative products (characterized by a limited availability of substitutes, rapid changes in market conditions and technology, low market maturity and short product life cycles) and functional products (characterized by a large availability of substitutes, slow change in market conditions and technology, high market maturity and long product life cycles). These products require respectively innovative and efficient supply chains, having distinctive characteristics as well. It might be clear that SC performance criteria differ as well: efficient chains focus on costs, while innovative chains aim for speed and flexibility. The type and effect of implementing IT based supply chain systems will be different for both types of chains as is reflected in the findings of Dehning et al. (2007). They show that firms in high-technology industries benefit more from their adoption of IT-based SCM system in terms of improvements of the financial performance.

Power and dependency have been taken into account in previous SCM research (e.g. Subramani, 2004; Prahinski and Benton, 2004; Saeed et al., 2005). Power might be a driving force in the forced adoption of a specific ICT tool. It is well-known that e.g. large retail chains force suppliers to use their systems. This is illustrated by the findings of Hill and Scudder (2002) and Devaraj et.al (2007), who find that ICT has no impact on customer coordination, but has a positive influence on supplier coordination. The possible explanation is that the more powerful customers (specifically in food chains) improve supplier coordination by having their suppliers adopt new IT systems and technologies. In turn, however the enforced use of such systems does not result in improvements in customer coordination for those less powerful suppliers.

Finally, a number of papers in our selection (e.g. Hill and Scudder, 2002; Olson and Boyer, 2003; Cagliano et al., 2003) directly show the influence of contextual factors such as size and position in the chain on ICT, SCM, SC performance and on their relationship. The effect of the firm's position in the supply chain is likely to be equivalent with the firm's power and dependency, which was discussed above.

2.6.2 Analysis of relationship findings

Within our sample of published research, only six papers were identified that do not confirm a positive effect of ICT. Here, we aim to find possible explanations that can both help us to better understand the effect of ICT and the mechanisms that improve performance. Such understanding will guide and improve future research.

Firstly, it seems that implementing ERP/MRPII is not always having direct, positive effects on performance. We submit, that nowadays, such systems have become a standard, which will not result in direct performance improvements. Evidence can be found in Table 2.2, which shows that four of the six non-confirming papers (Cagliano et al., 2006; Jeffers et al., 2008; Li et al., 2009; Ward and Zhou, 2006) incorporate ERP/MRPII in their measurement of ICT. Two other papers that incorporate ERP/MRPII, (Jayaram et al., 2000; Sanders and Premus, 2002) do find positive effects, but these are relatively early published papers. Still, performance improvements by means of ERP/MRPII can be reached if it becomes an organisational capability as the findings of Rai et al. (2006) suggest or in case its acts as a moderator of SCM practices, as the findings of Jeffers et al. (2008) show. More general, it suggests that ERP/MRPII will be beneficial if it really gets intertwined into organisational practices.

Another explanation for the limited effect of the usage of ERP/MRPII might be the internal focus of it, which does not directly relate to the cross-organisational nature of SCM and SC performance. Finally, all six non-confirming papers do not incorporate contextual factors. Therefore it is impossible to find out if the non-confirmation of the effect of ERP/MRPII can be attributed to different effects in different contexts. E.g. Welker et al. (2008) find in their study that a positive effect of ERP systems is more likely in a more stable business environment.

Secondly, it seems that more aggregated or general measures of ICT can be associated with positive results as is confirmed by all studies with that use such measures, except Zhang and Dhaliwaj (2009). That finding might indicate that in general ICT has benefits, but not all

aspects or types have a positive effect. In fact, our findings and discussion of measurements and relationships suggests that we do not yet fully understand which types, aspects and dimensions of ICT, SCM and performance influence each other and what the underlying mechanisms are. We will elaborate upon this point in the final section.

Thirdly, we think that another explanation for the mixed results can be found in how the relationship between ICT and SCM develops. Rather than believing that the pure presence of ICT will be beneficial, we need to distinguish different stages in the employment of ICT: ICT investment, ICT usage and ICT capability. The resource-based view (RBV) of the firm offers a useful framework to relate the SC performance of organizations to resources and capabilities in the three stages of ICT employment.

In the first stage of ICT employment, ICT investment, companies adapt themselves to ICT. However, the ICT employment is very limited and/or the companies invest only in standard ICT. According to the RBV such investments do not provide any sustainable advantage or performance gains as they can easily be imitated by competitors (Wooldridge and Floyd 1990; Powell and Dent-Micallef 1997; Zahra and Covin 1993). As a consequence, the expected benefits of ICT will be limited, and can even be negative as shown by Vlosky (1994) and Vlosky and Wilson (1994), who found short term disruptions in stable buyer-supplier relationships due to new technology adoption. In the second phase of ICT employment: ICT usage, the impact of ICT on SCM and some aspects of SC performance might become measurable. Nevertheless, in this stage, ICT is still not a company capability and the ICT usage can easily be mimicked by competitors. A competitive advantage can not be expected, even if the operational performance is increased (Sanders and Premus, 2002). In the third stage of ICT capability, a firm leverages its investments to create unique ICT resources and capabilities that determine a firms overall effectiveness (Clemons 1986, 1991; Clemons and Row 1991; Mata et al. 1995). Now, a sustainable advantage might be reached. ICT capability represents a competence that is not easily mimicked, as it is established through a combination of ICT and other resources of a firm. This explanation is confirmed in our papers, as the one paper that measures ICT investment (Ward and Zhou, 2006), does not find a relationship with SC performance, while the papers using ICT capability measures directly or indirectly confirm a relationship between ICT and performance. Finally, papers that use a measure related to ICT usage show inconsistent results, also in line with the RBV. An explanation might be that this stage is between ICT investment and ICT capability. Positive results indicate that already some benefits of the next stage might have been captured, while no effects show that a firm is still very close to the investment stage.

2.7 Conclusion and further research

This paper started with contradicting findings in the survey-based research on the relationship between ICT, SCM and SC performance. Based on the systematic exploration of papers from the top journals in the field, this paper presents a number of concerns and possible explanations for the findings presented in these papers. A majority of the papers confirm a positive relationship between either ICT and SC performance or ICT and SCM. However, our findings and analyses raise some doubts about the actual effect of ICT. Our main concerns can be summarised as follows:

- The main concepts ICT, SCM, and SC performance have been conceptualized and measured differently. While the effect of ICT is generally positive, it is hard to say which individual technologies positively affect specific performance measures and how the mechanisms underlying positive effects actually work;
- ICT has often been conceptualised and measured as an aggregate, holistic entity ignoring the difference between technologies (e.g. ERP, EDI) and ignoring the difference between inter-organisational and intra-organisational ICT;
- Contextual factors have been largely ignored, therefore little is known about the effects of specific types of ICT under different circumstances;
- The majority of the research so far, follows a similar path ICT-SCM-SC performance, e.g. ignoring possible interaction/moderating effects of ICT and SCM.

Some of the above conclusions are similar to the findings of earlier reviews in the field of supply chain management (e.g. Chen and Paulraj, 2004; Van der Vaart and Van Donk, 2008), but some specific and new elements related to ICT have been detected. Our overall conclusion is that the current survey-based research does not pay sufficient attention to the complexities and interrelationships between different aspects of supply chain integration and the role of ICT in improving different elements of SC performance. While the above concerns partly explain the initial confusion, an additional possible explanation is that disagreeing findings arise due to different stages in the employment of ICT, as supported by the resource based view of the firm.

Our review suggests a number of research implications. A first implication relates to methodology and measurement. Earlier research (Chen and Paulraj, 2004) has already aimed at establishing proven scales and constructs in SCM. Our present papers once more points at that as a major area of attention for future research. Our field can be brought forward by using

existing items, scales and constructs. That will enable comparison of different studies. While this has been noticed, but not implemented in the SCM area, it is also needed in the field of ICT. While using more existing and better validated scales would help, there are also concerns with respect to the use of single respondents, subjective scales, and self-reported performance results (see Forza, 2002), for an operations management related discussion and for a more general discussion Nunnally (1988). Possible remedies consist of the extension of existing methods and methodologies e.g. with the use of additional external, archival data from publicly available sources or the use of multiple respondents from different partners in the chain. However, we realize that in many cases that will be very hard.

A second, related point is the conceptualisation and measurement of ICT. We need to realise that ICT is not a single technology or holistic concept. That is hardly reflected in the current studies. We need to better investigate the effects of single technologies such as ERP, EDI, or internet; their interrelation and joint effect. Additionally; intra- and inter-organisational ICT need to be studied by addressing questions like what are the separate effects of intra- and inter-organisational ICT and how do they interact with SCM practices and with each other. Such research could possibly also try to detect how different technologies influence different aspects of SC performance. Our review suggests for example that ERP systems do not have a direct impact on general performance measures, but they might have a positive effect on a specific aspect such as reliable deliveries.

A third implication and suggestion for future work is to rethink and broaden our view on how ICT and SCM influence performance, how they interact and what their joint effect is. Most research considers only the effect of ICT via SCM (mediation) on performance. Future research should aim at following Jeffers et al. (2008) in their conceptualisation of SCM as a moderator of the relationship between ICT and performance. That reflects that positive effects of ICT can only be reached by implementing appropriate SCM practices. Similarly, in line with our second point, we need to investigate whether different models describe how SCM practices interact with different types of ICT e.g. intra-organisational ICT systems and inter-organisational ICT systems. Moreover, contextual variables need to be further incorporated to explore contingencies in the application of ICT and SCM and their relationship.

A fourth point is to incorporate organisational aspects. A recent case study by Ambrose et al. (2008) shows that the dynamics and interactions between SCM, and the use of certain ICT are also influenced by the development of the relationship between both the organisations and the persons interacting. Future research should aim at capturing such human and

organisational issues as well. A related issue, as pointed out earlier, is to explore how ICT can be turned into a capability of a company, following the resource-based view of the firm. Understanding such organisational aspects will be beneficial for getting organisations out of there ICT crises.

Finally, a meta-analysis (see for an example Mackelprang and Nair, 2010) could help to evaluate our sample of survey papers in a more quantitative way than the above analysis. A meta-study aims to categorize measurements and evaluates the aggregate findings of the whole collection of papers, while taking into account sample sizes etc. The categories distinguished in this paper can probably be a starting point. Another related idea might be to perform a similar review as this one for case-studies in this area.

The above analysis gives a number of future research possibilities, guidelines and directions. Our main target audience for this paper is the academic world. Still, the review also seems to give a few managerial implications. The review indicates that a direct effect of ICT is not always observable, but mediating and moderating effects are proven. It seems to suggest that ICT becomes beneficial if it is properly embedded in an organization and supported with appropriate practices. For example, only investing in an ERP system because all companies do, will probably not improve the competitive position of your business. However, if the investment is accompanied with restructuring the business processes and changing supply relationships, employing ERP might become a real organizational capability as is implied in the resource-based view.

CHAPTER 3※

THE DIFFERENT IMPACT OF INTER-ORGANIZATIONAL AND INTRA-ORGANIZATIONAL ICT ON SUPPLIER PERFORMANCE

3.1 Introduction

Companies that invest in ICT have a common question to ask. Do investments in ICT really improve supply chain (SC) performance? Numerous failures in practice have put doubt on this seemingly easy to answer question. It seems that ICT does have an impact on SC performance, but our understanding of why and how some companies do obtain positive results and others do not, is unclear. The main trust of this paper is that inter- and intra-organizational ICT play a different role in the improvement of SC performance. The use of inter-organization ICT (such as Internet, Electronic Data Interchange (EDI)) simply leads to more supply chain integration which in turn improves performance, whereas intra-organizational ICT (such as Material Resource Planning (MRP)/MRPII, Advanced Planning System (APS)) improves the quality of information and as such acts as a condition for effective supply chain integration. We define inter-organizational ICT as the information systems and technologies that link different organizations in a supply chain, and intra-organizational ICT as the information systems and technologies that plan, track, and order components and products throughout the manufacturing operation within the firm (Vickery et al., 2003). Supply chain integration is seen as the synergy reached through the integrative practices in the supply chain. Because the empirical setting for our investigations is a sample of Chinese manufacturers (suppliers) and their relationship with their principal buyer, the aspect of SC performance that we consider in this paper is supplier performance. Supplier performance indicates the service of the focal firm (supplier) provided to its customers (the buyers).

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The relationship between *generic ICT* and SC performance has been investigated in the literature. Although some studies do report a significant relationship, other studies find the effect of ICT on SC performance to be insignificant (Li et al., 2009; Jeffers et al., 2008) or only partially confirm an effect of ICT (Sanders and Premus, 2002; Lai et al., 2008). With respect to *inter-organizational ICT*, the past research seems to assert that inter-organizational ICT has a substantial, direct effect on SC performance (Da Silveira and Cagliano 2006; Frohlich and Westbrook, 2002; Iyer et al., 2009). Moreover, several studies show that inter-organizational ICT directly helps to improve integrative practices such as information sharing (Cagliano et al., 2005; Devaraj et al., 2007) or coordination between partners (Vickery et al., 2003), and then subsequently improves SC performance. For *intra-organizational ICT*, past studies show that intra-organizational ICT is significantly associated with superior performance at the firm level and relates to measures as cost, product quality, return on invest, and innovation (Cordero et al., 2009; Croteau and Raymond, 2004; Koc and Bozdag, 2009; Zhou et al., 2009). However, in the context of SC management, intra-organizational ICT has hardly been addressed and there seems no clear relationship with SC performance (Cagliano et al., 2006). A number of studies incorporate both intra-organizational ICT and inter-organizational ICT to capture their joint effect on SC performance. Typically, these studies do not present consistent, significant findings (e.g. Li et al., 2009; Jeffers et al., 2008). Based on the literature the conclusion seems justified that that intra-organizational ICT does not affect SC performance directly. However, the existing studies fail to explore other ways through which intra-organization ICT might influence SC performance. Kotha and Swamidass (2000) indicate that intra-organizational ICT controls manufacturing processes and generates unambiguous and precise process-related information, which enables integrative practices to be more effective. Consequently, we argue that intra-organizational ICT acts as a condition for effective supplier performance. In conclusion, the literature provides some support for the central theme of the paper that inter- and intra-organizational ICT play a different role in the improvement of SC performance: the first leading to more supply chain integration, which in turn improves performance and the second as a condition for effective supply chain integration.

We ground our study on the resource-based-view (RBV). The RBV provides guidance on how to identify ICT resources and explore the relationship between ICT resources and performance, which provides a cogent framework to evaluate the strategic value of information systems resources (Wade and Hulland, 2004). It helps us understand why some companies obtain better performance returns than others from similar ICT investments. RBV states that the organization is a bundle of resources. From that we built our basic premise that

ICT resources are not inevitably linked to enhanced performance, but generate competitive value only in combination with other organizational resources (Wade and Hulland, 2004). The interrelationships between ICT resources and other firm resources depend on the nature of the ICT resources (Wade and Hulland, 2004). This notion corresponds with the assumed different mechanisms through which intra- and inter-organizational ICT improve SC performance. As mentioned above, our sample focuses on suppliers and their relationship with their key buyers. Therefore, we focus on *supplier performance* in that relationship as the performance outcome variable of interest.

Our study makes several important contributions. The proposed perspective represents a first step to distinguish the roles of different types of ICT and their impact on performance. It offers a model in which both inter- and intra-organizational ICT are components as bundles of resources. We argue and empirically demonstrate that intra- and inter-organizational ICT resources interrelate with supply chain practices differently. As a consequence their role in improving supplier performance also differs. Our analysis results in a rich model that can serve as a blueprint for future research concerning the supplier performance implications of ICT. For decision makers, our findings demonstrate that the performance impact of ICT resources is shaped and influenced by the relationship of these ICT resources with other resources, specifically supply chain practices. Inter-organizational ICT leads to more supply chain integration which in turn improves supplier performance. Intra-organizational ICT improves the quality of information which provides the necessary conditions to make supply chain integration more effective.

The paper is organized as follows. First, the literature is reviewed to identify and define the key constructs of the research model and to develop the hypotheses for this study. The next section describes the methodology of the paper. The results of our study are presented in section four. The fifth section discusses our findings and presents the main conclusions and implications of our study.

3.2 Theoretical background

In this section, first the relevant literature is reviewed. Second, we discuss a typology of ICT resources and argue that the roles of intra-organizational ICT and inter-organizational ICT are different. Next, we further explore the mechanism through which intra- and inter-organizational ICT might improve SC performance. Finally, the main hypotheses of this study are developed.

3.2.1 Literature review

Although, there is a widely held belief that ICT plays a critical role in supply chain management (SCM) activities (Kearns and Lederer, 2003), the measurable impact of ICT applications on supply chain performance remains a topic of intense debate among managers and researchers.

The existing literature is inconclusive with respect to the direct effect of ICT on supply chain performance. A closer look at types of ICT captured makes clear that ICT has been approached differently: as intra-organizational ICT (Cagliano et al., 2006; Ward and Zhou, 2006), as inter-organizational ICT (Da Silveira and Cagliano, 2006; Hsu et al., 2008) and as a mixture of the two types of ICT (Bayraktar et al.,2009; Jeffers et al., 2008). Such differences make it hard to compare the results or to understand the ICT-SC performance relationship. Findings of Subramani (2004) suggest that indeed the types of ICT can be associated with differences in outcomes. This relates to the fact that the purpose of inter-organizational and intra- organizational ICT types is different and that this difference in purpose will be evident in how ICT is used (De Sanctis and Poole, 1994) and how ICT can be made effective.

While the above studies consider the direct impact of ICT on supply chain performance, several other studies investigated the possible underlying mechanisms linking ICT to supply chain performance. In these studies, supply chain integration acts as an intervening factor on the relationship between ICT usage and performance improvement (Grover et al., 1998). So far, the literature has examined two fundamentally different mechanisms for the relationship between ICT and SC performance and the intervening role of supply chain integration on that relationship. The first suggests that ICT usage influences supply chain performance primarily through its impact on supply chain integration (Frohlich and Westbrook, 2002; Devaraj et al., 2007; Hsu et al., 2008; Iyer et al., 2009). In other words, supply chain integration mediates the effect of ICT on performance. Although the majority of the literature supports this idea, a few studies address another perspective. This second perspective assumes a moderating effect of ICT on the strength of the relationship between supply chain integration and supply chain performance (Kim and Narasimhan, 2002; Jeffers et al., 2008). Such a moderating mechanism implies that ICT works as a condition for strengthening the relationship between integration and performance (Zhang et al., 2011).

Supply chain integration is supposed to be related to activities both within and between firms. Intra-organizational integration includes the management of internal material flows and

production processes, inter-organizational integration focuses on communication and coordination between firms. In line with this distinction between internal and external in a supply chain context, it is logical and well accepted to distinguish between two types of ICT: intra- and inter-organizational ICT (e.g. Hitt, 1999; Sarkis and Talluri, 2004; Savitskie, 2007). Sarkis and Talluri (2004) summarize the different requirements of companies in a supply chain with respect to internal and external systems and software. Savitskie (2007) distinguishes between internal and external logistics information technologies, and examines the relationship between these two types and different aspects of performance capabilities. Similarly, Ward and Zhou (2006) categorize ICT into within-firm and between-firm IT. They show that between-firm IT usage is directly associated with short lead times while within-firm IT is not. While names given to the two types of ICT differ, these studies show that it is important to distinguish between what we label as intra- and inter-organizational ICT. They also suggest that different underlying mechanisms can be associated with improved supply chain performance in case of intra- or inter-organizational ICT, in line with the central theme of this study. Therefore, based on the literature the conclusion seems justified that inter- and intra-organizational ICT interrelates with SC performance differently. In the next section we further develop the research framework derived from the RBV and ICT literature.

3.2.2 ICT in a RBV perspective

The RBV describes a firm as a specific collection of resources and capabilities that can be deployed to achieve competitive advantage (Barney, 1991). Firm resources are defined as all assets (tangible or intangible) belonging to or controlled by a firm that can be used to acquire competitive performance (Teece et al., 1997). Within Information Systems research the RBV has been employed to classify ICT resources along different attributes in order to understand which type of ICT resources are most likely to contribute to performance (Wade and Hulland, 2004; Leidner et al., 2009). In a comprehensive review, Wade and Hulland (2004) identify three categories of ICT resource: outside-in, inside-out, and spanning. As a result of the claim of Wade and Hulland (2004) that outside-in and spanning resources have similar resource attributes, later studies only distinguish between two categories of organizational resources, namely internal and external (Hulland et al., 2007; Goh et al., 2007b; Liang et al., 2010).

According to Liang et al. (2010, p. 1144) internal resources "help firms to enhance internal control capabilities, strengthen cooperation performance between the departments, and improve capacity of the system and development". Thus, internal resources can enhance the capabilities of internal firm operations (Wade and Hulland 2004). External resources help

firms to adapt to the external environment and to improve the ability to work with external partners for cooperation and information sharing (Liang et al., 2010). External resources are mainly concerned with partnership management, market response, and organizational agility (Hulland et al., 2007). They foster capabilities for quick response and flexibility to deal with changes in market conditions (Goh et al., 2007a).

In line with the distinction between internal and external resources, we distinguish between inter- and intra-organizational ICT. Inter-organizational ICT represents the external ICT resources. These resources influence the way that organizations conduct business by improving the process of information sharing and cooperation between partners in the supply chain. Intra-organizational ICT comprises all internal ICT resources which are used to control and monitor internal processes by supporting computerization of the operational process.

The RBV suggests that ICT does not directly contribute to distinctive capabilities. To enable a firm to gain competitive advantage these technologies should be used to realize the full competitive potential of other resources of the firm that are valuable and costly to imitate. For this reason, any effort to study the competitive implications of ICT should also include those resources which are influenced or enhanced by ICT resources. Supply chain integration has been facilitated by the advances in ICT (Subramani, 2004). We take two aspects of supply chain integration into account: information sharing and cooperation. Cooperation implies a partnership relationship based on a joint problem-solving capability (Goffin et al., 2006), and information sharing helps companies to improve the capability to respond to changing market requirement and communicated among trading partners across company borders (Howard and Squire, 2007). These two aspects are regarded as important aspects of supply chain integration (Horvath, 2001; Van der Vaart and Van Donk, 2008).

The impact of ICT depends on its interrelationships with other resources (Bresnahan et al., 2002; Zhu, 2004; Jeffers et al., 2008; Benitez-Amado and Walczuch, 2012). Inter- and intra-organizational ICT are fundamentally different types of resources and they contribute to supply chain performance improvement in a different way. As mentioned earlier, our sample focuses on suppliers and their relationship with their key buyers. Therefore, we focus on *supplier performance* in that relationship as the outcome variable of interest. In the next section, a set of hypotheses are developed to investigate the influence of inter- and intra-organizational ICT on supply chain integration itself or on the on effect of supply chain integration on supplier performance.

3.2.3 Development of Hypotheses

The first subsection is devoted to the direct effects of intra- and inter-organizational ICT on supplier performance. In the second and third subsections, we develop hypotheses about how inter- and intra-organizational ICT interrelate with supply chain integration to improve supplier performance.

The direct effect of intra- and inter-organizational ICT on supplier performance

In the above, we distinguished between internal and external resources that can be associated with intra- and inter-organizational ICT. Hong (2002) describes inter-organizational ICT as ICT that transcends organizational boundaries, enabling information to flow from one organization to another. Inter-organizational ICT can be characterized as information technologies and/or practices that facilitate logistics-related communication and information exchange between supply chain partners. It also relates to systems that enable firms to obtain information directly from customers to facilitate operations (Savitskie, 2007). In contrast, intra-organizational ICT falls into the domain of office and factory automation systems that organize work more efficiently (Ryssel et al., 2004). Intra-organizational ICT is used for planning, tracking, and ordering components and products throughout the manufacturing operation within the firm (Vickery et al., 2003). These application software packages have their roots in manufacturing resource planning systems and support a variety of transaction-based functions. The different orientation of both types of ICT has consequences. Inter-organizational ICT is usually regarded as a medium to transfer information across organizational boundaries and therefore directly increases SC performance (Rai et al., 2006; Rosenzweig, 2009; So and Sun, 2011). In contrast, intra-organizational ICT needs to be more organizationally embedded to be effective (Zhou et al., 2009; Jeffers et al., 2008).

Wade and Hulland (2004) indicate that there is a fundamental difference between the impact of internal and external ICT resources on performance. In particular, they propose that external ICT resources will have a stronger direct impact than internal ICT resources on performance. This might specifically be true for supplier performance. This proposition seems to be confirmed by empirical studies. Several studies confirm that there is a significant impact of inter-organizational ICT on supplier performance. Da Silveira and Cagliano (2006) find that adopting inter-organizational ICT improves performance in flexibility, quality, cost, and delivery. Lai et al. (2008) indicate that inter-organizational e-integration, based on the use of EDI can be positively associated with a decrease in logistics cost and improved service performance. With regard to intra-organizational ICT, some studies find that intra-

organizational ICT in particular advanced manufacturing technology helps firms to achieve higher product quality and to cut product cost (Koc and Bozdag, 2009; Zhou et al., 2009). However, the empirical studies do not report significant effects of intra-organizational ICT on supplier performance. Ward and Zhou (2006) indicate that "within-firm" IT implementation does not help to reduce customer lead time directly. In their study within the retail industry, Powell and Dent-Micallef (1997) find that intra-organizational ICT, such as point-of-sale terminals do not have a significant effect on performance. Therefore, our first hypotheses are:

H1a: Inter-organizational ICT has a positive and direct relationship with supplier performance.

H1b: Intra-organizational ICT has no direct relationship with supplier performance.

The effect of inter-organizational ICT on supply chain integration and supplier performance

Inter-organizational ICT is a medium that improves sharing information about markets, production requirements, inventory levels, and production and delivery schedules (Webster, 1995). Li and Lin (2006) show that the higher the usage of inter-organizational ICT, the higher the level of information sharing in the chain. Sanders (2007) shows that a firm's usage of e-business technologies has a direct and positive impact on inter-organizational integration via information sharing. In addition, information sharing allows supply chain members to improve forecasts, synchronize production and delivery, coordinate inventory-related decisions, and develop a shared understanding of performance bottlenecks (Lee and Whang 1998; Simchi-Levi et al., 2000). Cachon and Fisher (2000) find that sharing demand and inventory data can shorten the order processing lead time. Therefore, we propose the following hypothesis:

H2a: Inter-organizational ICT has a positive relationship with supplier performance via information sharing.

Inter-organizational ICT improves inter-firm cooperation as it aids supply chain partners in reaching joint decisions, synchronized communication, information recollection, and standardization (Quelch and Klein, 1996). It is indicated that cooperation among firms is limited by the transaction costs of managing the interaction (Sanders, 2007). The application of inter-organizational ICT reduces transaction costs and correspondingly promotes the cooperation among firms (Tan et al., 2010). Klein et al. (2007, p. 621) state that "cooperative strategies provide a basis for theorizing how both significant levels and symmetry in

information sharing within strategic supply chain relationships can result in greater performance across the dyad". A higher level of inter-organizational cooperation is found to be strongly linked to buyer satisfaction and the buyer's assessment of relationship's performance (Johnston et al., 2004), which can be expected to be associated with supplier performance. The foregoing analyses all strongly suggest that inter-organizational ICT contributes to better supplier performance via cooperation. Therefore, we propose the following hypothesis:

H2b: Inter-organizational ICT has a positive relationship with supplier performance via cooperation.

Intra-organizational ICT as a condition for effective supply chain integration

Intra-organizational ICT is supposed not to change external processes directly, but it can be an important variable in the relationship between supply chain integration and supplier performance (Grover et al., 1998). Intra-organizational ICT improves the capability for data processing within an organization and provides high-quality information. Information quality includes such aspects as the accuracy, timeliness, adequacy and credibility of information (Monczka et al., 1998). While information sharing and cooperation are important, the significance of their impact depends on information quality (Li and Lin, 2006). Jarrell (1998) notes that sharing information within the entire supply chain can create flexibility, but that accurate and timely information is required. Cooperation reflects how supply chain partners integrate decision making and form alliances in order to best exploit market conditions and improve competitiveness (Arunachalam et al., 2003). A high level of cooperation between partners requires that firms have the capability to generate visibility of their operation processes (Barratt and Oke, 2007). The more accurate, timely and adequate operational information managers have, the better they know what happens within the firm, and the better they can cooperate with partners in joint decision making. It has been indicated that information notoriously suffers from delay and distortion as it moves up the supply chain (Feldmann and Müller, 2003; Li and Lin, 2006). To reduce information distortion and improve the quality of information in the supply chain, the available data has to be as accurate as possible. Li and Lin (2006) indicate that the higher the usage of intra-organizational ICT, the higher the level of information quality in SCM. The higher information quality makes information sharing and cooperation between partners more effective and leads to improved supplier performance. As a result we can formulate the following hypotheses:

H3a: Intra-organizational ICT will moderate the relation between information sharing and supplier performance. More specifically, the relationship will be stronger under high usage of intra-organizational ICT than under low usage of intra-organizational ICT.

H3b: Intra-organizational ICT will moderate the relation between cooperation and supplier performance. More specifically, the relationship will be stronger under high usage of intra-organizational ICT than under low usage of intra-organizational ICT.

3.3 Methodology

In this section, we present our methodology by discussing the development of the questionnaire and the data gathering. In addition, the resulting sample and data analysis are discussed.

Development of Questionnaire

The measures used for the different constructs in this study were derived or adapted from earlier work in the fields of SCM and ICT. The items used for measuring inter-organizational ICT were taken from Li and Lin (2006) and Saeed et al. (2005). EDI was not included in the measurement, as it appears that due to the fact that Chinese companies started large scale ICT implementation a decade later than companies in the Western part of the world, they bypassed traditional EDI and directly moved to contemporary ICT solutions based on internet and extranet. Internet was chosen as being open access, while extranet represents the extension of a private network onto the Internet with special provisions for authentication, authorization and accounting. In other words, Extranet can be considered as a replacement or equivalent of EDI. The items used for measuring intra-organizational ICT were adapted from Ward and Zhou (2006). Information sharing by the buyer was measured using adapted items from De Toni and Nassimbeni (2000), Frohlich and Westbrook (2002), and Giménez and Ventura (2003). The selected items relate to the extent to which the buyer communicates sales forecasts and (changes in) production plans to the supplier. The cooperation construct consisted of the items from Johnston et al. (2004), which reflect how supply chain partners integrate decision making. Important aspects are joint responsibility and willingness to diverge from fixed contractual terms as conditions change. As our target population is suppliers, we focus on how well the supplier satisfies the buyer's requirements. Supplier performance was measured by adapting five items from Giménez and Ventura (2003). These items reflect the buyer's satisfaction with respect to the order quantities, special requirements, delivery lead times, delivery reliability and advance notifications about late deliveries and

stock-outs. The main reason for the focus on service aspects of performance is that ICT fosters capabilities for quick response and flexibility to deal with changes in market conditions (Goh et al., 2007a).

The original questionnaire in English was translated into Chinese and translated back into English separately by three different academics in Operations Management. Subsequently, an expert in the operation field was asked to compare these three English questionnaires to make sure that in the translation process the content of English and Chinese versions were not altered. In the pre-pilot study, the questionnaire was reviewed by five academics and evaluated through structured interviews with six executives for readability and ambiguity. They were asked to comment on the clarity and expression of the items in order to make sure that no further changes were needed.

Sample and Data Gathering

Recently, several studies (e.g. Flynn et al., 2010; Jiang et al., 2009; Li et al., 2009), mostly co-authored by Chinese researchers have researched contemporary supply chain issues in Chinese companies. These studies represent the growing interest in and significance of Chinese manufacturing firms as being "the manufacturers of the world". Based on the current position of Chinese manufacturing, we believe that this research yields generalizable results. Another reason for gathering data in China was convenience, as one of the authors is based in China. This guaranteed good access to organizations and as such helped to ensure a high response rate. To further assure a high response, we choose to work with two institutions that were willing to help us to get access to companies. The two institutions were the China IT promotion institution and the Zhejiang Province enterprise association. The China IT promotion institution aims to promote ICT application in industry. It is an intermediary between the government and the companies, as well as between ICT-providers and industries. Its membership includes nation-wide manufacturing firms in China. Zhejiang Province is one of the largest industrial areas in China. An important manufacturing association in this province is the Zhejiang Province Enterprise Association. The members of these institutions formed the initial population for our study. As this study is aimed at industrial suppliers, the first step was to check whether the contacted companies were indeed industrial suppliers. That resulted in 278 companies from the China IT promotion institution and 386 companies from the Zhejiang Province enterprise association.

In accordance with a study by Phillips (1981) we aimed for high ranking respondents as they are believed to be a more reliable source of information than lower ranked respondents. Consequently, the questionnaires were to be filled out by either the supply chain manager, Chief Information Officer (CIO) or top level executive, given the diversity of subjects addressed. They were asked to fill out the questionnaire with regard to their most important buyer. The data gathering took place in several steps. We distributed the hardcopy version at the annual conference of the China IT promotion institution. In the process it was checked whether the person attending the conference was indeed a suitable respondent. If not, the questionnaire was posted. For the target companies of the Zhejiang province enterprise association, the printed version was posted to the companies directly. The above two steps were executed at the same time. Responses from the conference were received first. Non-respondents were sent a reminder together with the electronic version of the survey. Data collection took place from December 2007 to April 2008. During the conference, we distributed 152 questionnaires and got 124 responses (response rate of 81.6%). An additional 43 companies responded to the posted survey sent to the 126 remaining target companies of the China IT promotion institution (response rate of 34.1%) The response from the Zhejiang Province enterprise association was 44.5% (172 returns from the 386 sent).

Our final sample contains 320 respondents, due to incompletely returned questionnaires. Therefore the overall response rate was 48.2% (320 out of 664). Table 3.1 shows the distribution of respondents across functions. The distribution of the SIC codes is provided in Table 3.2. The data were examined for non-response bias by exploring differences between early and late respondents (Armstrong and Overton, 1977). The ANOVA test does not show significant differences for the category means for annual sales revenues, number of employees, the unit selling price of the primary product ($p \leq .05$).

Table 3.1 Respondents

The respondent position	Number	Percent
President/Vice President	54	16.8
Supply Chain Manager	99	30.8
Chief Information Officer	96	29.9
Director	67	20.9
Others	4	1.6
Total	320	100

Table 3.2 Industry classification

Two-digit SIC	Number	Percent
20. Food and kindred products	21	6.6
22. Textile mill products	47	14.7
23. Apparel and other product made from fabrics and similar	32	10
25. Furniture and fixtures	8	2.5
26. Papers & allied products	13	4.1
27. Printing, publishing and allied industries	7	2.2
28. Chemicals and allied products	29	9.1
29. Petroleum refining and related products	21	6.6
30. Rubber and miscellaneous plastics products	24	7.5
32. Stone, clay, glass, and concrete products	3	0.9
33. Primary metal industries	9	2.8
34. Fabricated metal products except machinery and transportation equipment	17	5.3
35. Industrial, commercial machinery and computer equipment	23	7.2
36. Electronic, other electrical equipment and components, except computer equipment	31	9.7
37. Transport equipment	15	4.7
38. Measuring, analyzing, and controlling instruments; Photographic, medical, and optical goods, etc.	11	3.4
39. Miscellaneous manufacturing industries	9	2.8
Total	320	100

Data Reduction and Analysis

In order to extract the underlying constructs from our measured items, we conduct an exploratory factor analyses. The examination of Kaiser-Meyer-Olkin (KMO) value (.85) indicates satisfactory adequacy for a factor analysis. Then, a Principal component analysis (PCA) with a varimax rotation is conducted with all the items. In order to test our hypotheses, hierarchical regression analysis is performed using SPSS. We adopted Baron and Kenny's (1986) three-step hierarchical regression analysis procedure to test the mediating effect. With regard to the hypothesized moderating effects, we centered the main effects prior to the analyses, to avoid multicollinearity problems (Cohen et al., 2003).

3.4 Results

In this section, we present the results of the factor analysis and subsequently the tests of our hypotheses.

Factor Analysis

The final results of the PCA are given in Table 3.3. Five factors emerge with eigenvalues greater than 1, accounting for 66.07% of the variance. The items with loadings greater than or equal to 0.4 were regarded as significant and retained following the convention advocated by Nunnally (1988). Only one item "the internet usage" has a cross loading larger than .40 (.41) on another component. Considering that internet usage is clearly distinct from the use of intra-organizational ICT, we chose not to remove this item. Most Cronbach's coefficient alphas are around .80, while the value of supplier performance (.67) is close to the widely accepted cutoff value of .70 and greater than the minimum recommended (.60) (Nunnally, 1988). Therefore, we felt save to conclude that our measures are reliable.

The first factor, labeled as intra-organizational ICT, includes four technologies and systems used within companies to manage, plan, and control manufacturing systems. The second factor is labeled inter-organizational ICT. It comprises technologies for the communication between companies in a supply chain. The third factor (information sharing) contains four items related to the exchange and use of information between the buyer and the supplier. Cooperation (Factor 4) relies on three items reflecting how companies value their relationship and react to problems and new, emerging situations with their main buyer. Finally, supplier performance (Factor 5) is measured by five items that reflect delivery in time and quantity, and service performance to the key buyer including response to special requirements and notification of delays.

Table 3.3 Results of Principal Components Analysis

Items	Factor				
	1	2	3	4	5
F1***: Intra-organizational ICT***: **α =.77** (Please indicate to what extent these technologies used in your company) [a]					
MRP/ MRP II			**.81**		
Advanced Planning and Scheduling (APS)			**.78**		
Computerized Integrated Manufacturing (CIM)			**.70**		
Manufacture Execution System for Production Management			**.70**		
F2: ***Inter-organizational ICT***: **α =.76** (Please indicate to what extent these technologies used in your company)[a]					
Use electronic mail with the key buyer					**.87**
Have an internet connection with the key buyer	41				**.73**
Have an extranet connection with the key buyer					**.61**
F3: ***information sharing***: **α =.89** (Please indicate the degree to which you agree with each statement) [b]					
Receive information about changes in the production plans of our key buyer at once.	**.84**				
Receive information about the sales forecasts from our key buyer	**.79**				
Receive information about the production plans of our key buyer.	**.75**				
Receive information about stock levels from our key buyer	**.72**				
F4: ***Cooperation*** : **α =.87** (Please indicate the degree to which you agree with each statement :) [b]					
The parties would rather work out a new deal than to hold each other to the original terms		**.87**			
The parties will be open to modifying their agreement if unexpected events occur		**.81**			
Problems that arise in the course of this relationship are treated as joint rather than individual responsibilities.		**.80**			
F5: ***Supplier performance***: **α =.67** (Provide an indication of the improvement of your organization's performance relative to three years ago. In case the relationship with your key buyer is shorter than three years, please refer to the improvement of your performance since the start of the relationship :) [c]					
Responds to the special requirements of the key buyer				**.66**	
Notifies the key buyer in advance about late deliveries or stock-outs				**.66**	
Delivers on the agreed date				**.64**	
Provides the quantities ordered by the key buyer				**.63**	
Has a short delivery lead time				**.61**	
Eigenvalue	5.80	2.08	1.91	1.73	1.03
Percentage of variance explained	30.51	41.46	51.52	60.62	66.07

KMO: .85
a: Scale: No use -significant use (1-5)
b: Scale: Totally disagreed- totally agreed (1-5)
c: Scale: Far worse-Far better (1-5)

Testing Hypotheses

Table 3.4 displays the means, standard deviations, and correlations of the variables. We examined the individual variables and the variates to check for linearity, homoscedasticity, and normality (Hair et al., 2009). The analyses did not reveal any significant problem with respect to the assumptions to use regression analysis. Regression diagnostics revealed no multicollinearity among the variables. Specifically, the variance inflation factors (VIF) associated with each regression coefficient ranged from 1.097 to 2.743, showing no relevant multicollinearity.

Table 3.4: Univariate Statistics and Pearson Correlations among the Variables

Variable	Mean	SD	1	2	3	4	5	6	7
1. No. of Employees	3.17	.89							
2. Annual Sales	3.12	1.11	.79**						
3. Inter-organizational ICT	3.04	.87	.24**	.30**					
4. Intra-organizational ICT	2.32	.79	.53**	.55**	.34**				
5. Information sharing	2.48	.96	.31**	.29**	.56**	.28**			
6. Cooperation	2.96	.94	.25**	.20**	.31**	.28**	.52**		
7. Supply chain Performance	4.02	.39	.20**	.14**	.21**	.17**	.28**	.20**	

** Correlation is significant at the .01 level (2-tailed).

Table 3.5 Results of Regression Analyses: Direct Model

Steps		Supplier performance		
	Variables	1	2 (1)	2 (2)
1	Number of employees	.22*	.22*	.20*
	Annual sales	-.03	-.08	-.07
2 (1)	Inter-organizational ICT		.18**	
2 (2)	Intra-organizational ICT			.10
	R^2	.04	.07	.05
	Adj R^2	.03	.06	.04
	F	6.45**	7.64***	5.00**
	Change in R^2	.04	.03	.01
	Change in F	6.45**	9.66**	2.06

Standardized regression coefficients are reported.
Notes: *p<.05; **p<.01; ***p<.001

Tables 3.5, 3.6, 3.7 and 3.8 present the results of the analyses. The number of employees and annual sales are included as control variables. Hypotheses 1a and 1b refer to the *direct* effect of inter- and intra-organizational ICT. As can be seen in Table 3.5, inter-organizational ICT has a significant impact on supplier performance (β=.18, p<.01) while there is no significant direct relationship between intra-organizational ICT and supplier performance (β=.1, n.s.). Thus, both Hypothesis 1a and 1b can be accepted.

Table 3.6 Results of Regression Analyses: Mediator Model

Steps		Supplier performance		
	Variables	1	2	3
1	Number of employees	.22*	.22*	.17
	Annual sales	-.03	-.08	-.07
2	Inter-organizational ICT		.18**	.07
3	Information sharing			.19**
	Cooperation			.05
	R^2	.04	.07	.1
	Adj R^2	.03	.06	.09
	F	6.45**	7.64***	6.95***
	Change in R^2	.04	.03	.03
	Change in F	6.45**	9.66**	5.58**

Sobel test statistics is 3.13, the p value is .001.
Standardized regression coefficients are reported.
Notes: *p<.05; **p<.01; ***p<.001

Table 3.6 shows the results of the analyses conducted to test the impact of *inter-organizational ICT*. Hypotheses 2a and 2b are tested following the approach suggested by Baron and Kenny (1986). Firstly, inter-organizational ICT has significant relationships with information sharing (β=.52, p<.001) and cooperation (β=.27, p<.001). Secondly, information sharing has a significant positive effect on supplier performance (β=.19, p<.01). However, it is shown that cooperation does not have a significant relationship with supplier performance (β=.05, ns). Therefore, H2b is rejected. Finally, with regard to information sharing, the results show that adding the mediator in the regression significantly reduces the effect of inter-organizational ICT, as is confirmed by the Sobel test. Information sharing fully mediates the effect of inter-organizational ICT, as can be deduced from the change in β-coefficient from significant to insignificant (β=.07, n.s.). Thus, H2a is supported.

Tables 3.7 and 3.8 present the results regarding the moderation effect of *intra-organizational ICT*. Table 3.7 shows that the interaction effect between intra-organizational ICT and information sharing with supplier performance is significant (β=.25, p<.001), which supports Hypothesis 3a.

To better understand the effect, the regression equations were rearranged into simple regression of information sharing on supplier performance, with given conditional values of intra-organizational ICT (M+1SD; M-1SD), which are shown in Figure 3.1. We find that in a situation with low intra-organizational ICT, information sharing is insignificantly related to supplier performance (simple slope test: β=.11, n.s.), while in a situation with high intra-organizational ICT, intra-organizational ICT is positively related to supplier performance (simple slope test: β=.41, p<.001).

Table 3.7 Intra-Organizational-ICT as Moderator on the relationship between Information Sharing and Supplier Performance

Steps	Supplier performance				
	Variables	1	2	3	4
1	Number of employees	.22*	.17	.16	.20*
	Annual sales	-.03	-.06	-.08	-.10
2	Information sharing (IS)		.25***	.24***	.24***
3	Intra-organizational ICT (Intra-ICT)			.06	-.13
4	Intra_ICT x IS				.25 ***
	R^2	.04	.10	.10	.13
	Adj R^2	.03	.09	.09	.11
	F	6.45**	11.05***	8.48***	9.08***
	Change in R^2	.04	.06	.00	.03
	Change in F	6.45**	19.49***	.81	10.47***

Standardized regression coefficients are reported.
Notes: *p<.05; **p<.01; ***p<.001

Table 3.8 Intra-Organizational-ICT as Moderator on the relationship between Cooperation and Supplier Performance

Steps	Supplier performance				
	Variables	1	2	3	4
1	Number of employees	.22*	.19*	.17	.20*
	Annual sales	-.03	-.03	-.06	-.08
2	Cooperation (CO)		.16**	.15**	.19**
3	Intra-organizational ICT (Intra-ICT)			.06	-.04
4	Intra_ICT x CO				.16*
	R^2	.04	.06	.07	.08
	Adj R^2	.03	.05	.05	.07
	F	6.45**	7.02***	5.49***	5.66***
	Change in R^2	.04	.02	.01	.02
	Change in F	6.45**	7.87**	.91	6.01*

Standardized regression coefficients are reported.
Notes: *p<.05; **p<.01; ***p<.001

Finally, as Table 3.8 shows, the interaction between intra-organizational ICT and cooperation with supplier performance is significant (β=.16, p<.05), which is consistent with Hypotheses 3b. Here, we performed the same additional analysis as in the case of information sharing (see Figure 3.2). We find that cooperation is insignificant related to performance (simple slope test: β=.08, n.s.) in a situation with low intra-organizational ICT application, while cooperation is positively related to supplier performance in a situation with high intra-organizational ICT application (simple slope test: β=.32, p<.01). Figure 3.3 summarize all the results of hypotheses in the models.

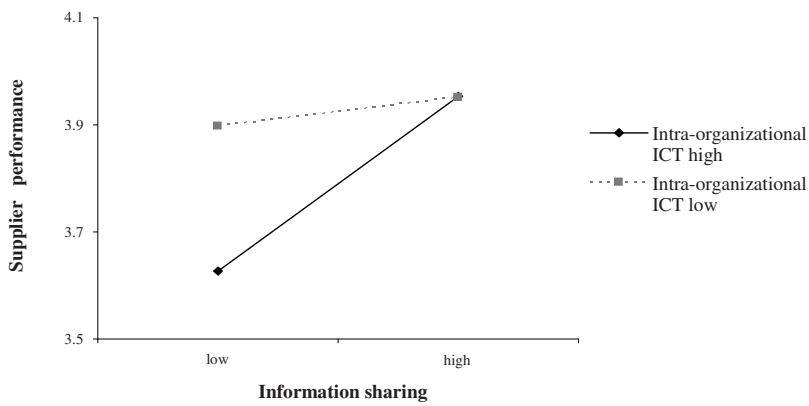

Figure 3.1: Effects of interaction of information sharing and intra-organizational ICT on supplier performance

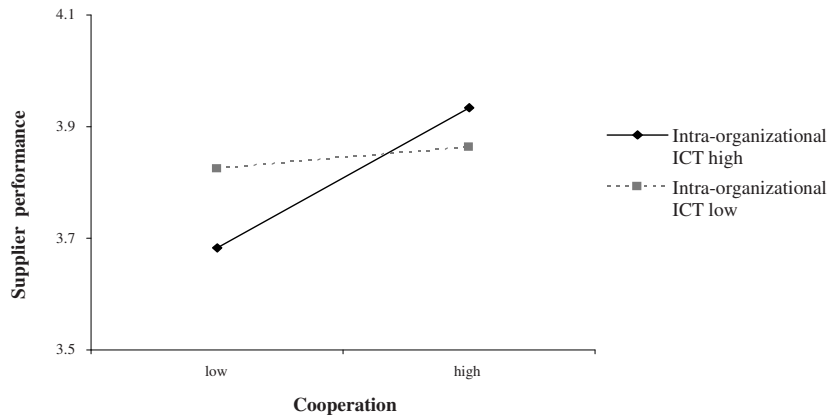

Figure 3.2: Effects of interaction of cooperation and intra-organizational ICT on supplier performance

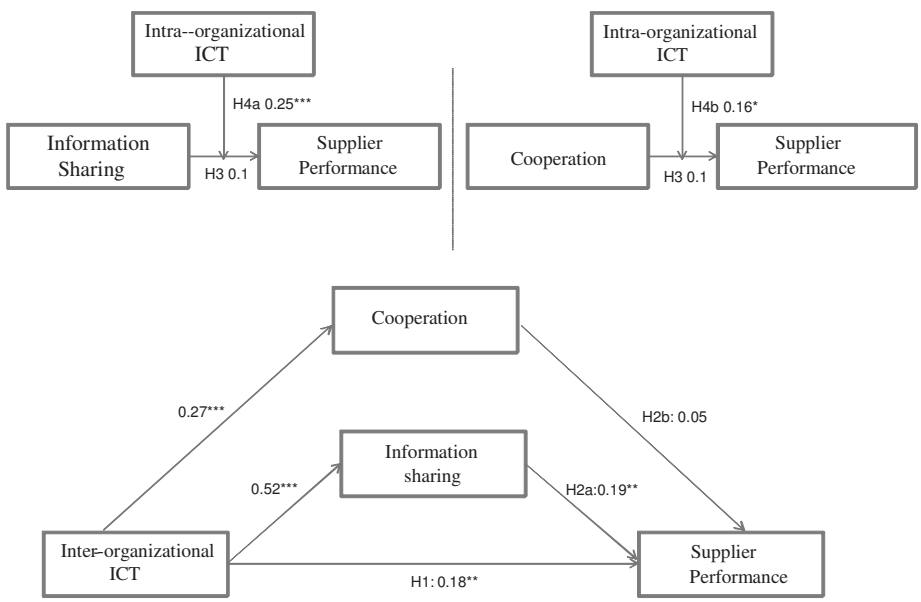

Figure 3.3: Summary of research models and results

3.5 Conclusion and discussion

The aim of this paper is to investigate the role of intra- and inter-organizational ICT in improving supplier performance. Specifically, we aim to understand the differences in the relationship between these two types of ICT and supply chain practices in improving performance. We provide evidence that both intra- and inter-organizational ICT are crucial for performance improvement, but that their roles differ substantially. Those differences are manifest in how each of the two types of ICT relates to supply chain practices. More specifically, supply chain practices *mediate* the positive effect of inter-organizational ICT on performance. In other words, inter-organizational ICT leads to more supply chain integration which in turns improves supplier performance. In contrast, intra-organizational ICT *moderates* the effect of supply chain practices on supplier performance. To put it differently, intra-organizational ICT provides a condition under which supply chain practices are more effective. These findings help to understand the mixed results reported in the literature with respect to the relationships between ICT and supplier performance and the role of supply chain integration in that relationship.

The above findings are in line with our expectations. However, the interaction effects for intra-organizational ICT deserve specific attention. Upon closer inspection, it appears that Figures 3.1 and 3.2 display a surprising effect. For low levels of integration (either information sharing or cooperation) it appears that organizations reach a higher performance if the level of intra-organizational ICT is low than if the level of intra-organizational ICT is high. Only if the supply chain practices increase to a higher level, performance for low and high levels of intra-organizational ICT are almost equal (for information sharing) or the performance for high levels of intra-organizational ICT exceeds the performance that can be reached under low levels of intra-organizational ICT (for cooperation). In addition, the figures also show that there is no performance effect of increased cooperation and information sharing in the case of low levels of intra-organizational ICT. This suggests that, as argued earlier, high quality information is indeed an important condition for effective supply chain practices. However, our findings also suggest that an increase in the use of systems like ERP and other internally oriented ICT systems has a certain danger. It might decrease performance unless increased use of intra-organizational ICT is accompanied with a high level of integrative practices. These findings suggest that negative experiences with the implementation of MRP/ERP-systems and the associated negative effect on supplier performance can be attributed to insufficient employment of integrative practices. Nurmilaakso (2007) characterizes this as a mismatch between a high internal ICT-level with a

low level of integrative practices. These findings seem to be important for practice as well. In contemporary business practice having intra-organizational ICT such as a MRP/ERP-system is more or less a standard practice for many suppliers and often a requirement to qualify as a supplier for major buyers. Our findings suggest that this will not automatically improve supplier performance, but that it forms a solid base on which integrative practices can be built that will improve that performance.

These finding confirm once more the value of the RBV perspective in ICT and supply chain management research. The RBV perspective argues that internal resources such as intra-organizational ICT contribute to internal coordination and internal performance improvement. However, if complemented with appropriate other organizational resources such as building relationships with key buyers through enhanced information sharing and cooperation, intra-organizational ICT can also be associated with improving the competitive position through its positive effect on external performance.

Another unexpected finding is that cooperation does not mediate the effect of inter-organization ICT on supplier performance. To better understand this result, we also tested a model with cooperation as the only mediator. In that case, cooperation mediates the relationship between inter-organizational ICT and supplier performance. However, if information sharing is added to the model, the mediating role of cooperation becomes insignificant. However, there is a high correlation between information sharing and cooperation (0.52, $p<0.01$), which shows that there is a significant relationship between cooperation and information sharing. This can possibly imply that the mediating role of cooperation for the impact of intra-organizational ICT on supplier performance is made effective via information sharing. It explains why, the mediation role of cooperation becomes insignificant if both variables are tested. Further studies can explore models that incorporate both aspects of supply chain integration and their relationship. Taking together the separate results for the mediation of cooperation and information sharing and the above discussion, we feel save to conclude that supply chain practices mediate the effect of inter-organizational ICT on supplier performance.

Two important academic implications can be derived from this study. First, this study provides support for the idea that distinguishing intra- and inter-organizational ICT helps to acquire a better understanding and assessment of the contribution of ICT to supplier performance improvement. Specifically, it is important to understand that each of the two types of ICT has a distinctive role and that understanding these roles will help to make – each

type of - ICT more effective. Earlier research has distinguished between mediating and moderating models in the relationship between ICT and SCM, but without linking those models to different types of ICT and the different underlying mechanisms for each type of ICT. Based on the results of this study, future research should distinguish between intra- and inter-organizational ICT to avoid confusing effects of ICT as have been reported in the past (see Zhang et al., 2011).

Second, the present study confirms that a number of the concepts proposed and developed in the RBV can be translated and employed in the context of ICT and SCM. Specifically, the notions of distinguishing internal and external oriented resources and employing the concept of bundles of resources are worthwhile. Applying those concepts in this study provides insight in the different underlying mechanisms through which both internal and external ICT resources contribute to the performance improvement in a supply chain relationship. Additionally, we explore how different bundles of resources lead to a competitive advantage. It is confirmed that organizational resources such as supply chain practices interrelate with ICT, but that the specific way in which a bundle of ICT and organizational resources turns out to be effective differs for inter-organizational and intra-organizational ICT. The use of inter-organization ICT (such as Internet or Electronic Data Interchange (EDI)) simply leads to more supply chain integration which in turn improves performance, whereas intra-organizational ICT (such as Material Resource Planning (MRP)/MRPII or Advanced Planning System (APS)) improves the quality of information and as such acts as a condition for effective supply chain integration. Together, this provides a framework grounded in the RBV-theory for understanding the role of ICT resources and it proves the value of ICT through empirical verification.

Our study provides also an aid for managers to rethink their ICT strategy in the context of supply chain management and performance improvement. Our findings suggest that implementing ICT needs to be tailored to the two types distinguished in this study: inter- and intra-organizational ICT. Specifically, inter-organizational ICT will most likely be beneficial without additional investment in improved supply chain practices. However, implementing intra-organizational ICT seems not to enhance SC performance directly, but it acts as a condition - by improving information accuracy and availability – to enhance the effectiveness of supply chain integration on SC performance.

Limitations and Further Research

This study investigates the separate effects of intra- and inter-organizational ICT, without investigating possible interaction between these two types of ICT and supply chain processes. Future research might seek to explore the mechanisms that explain the mutual effects of supply chain integration and both types of ICT on performance. Such research might also address another possible limitation of this paper by incorporating other aspects of supply chain integration than the two supply chain practices that were investigated here, for example communication or trust. Finally, in this paper we only look at the impact of ICT and integration on service performance. Of course, ICT and integration also have an impact on other performance measures, such as supply chain costs, return of investment (ROI) or market share. Therefore, it is relevant to extend this research and include the effects of ICT and SCM on various other performance measures.

CHAPTER 4※

INTER-ORGANIZATIONAL ICT AND SUPPLIER PERFORMANCE: A MODERATED MEDIATION MODEL OF INTEGRATION AND UNCERTAINTY

4.1 Introduction

Although the benefits of inter-organizational information and communication technology (ICT) have been studied in the literature, our understanding of why and how some supply chains achieve a better performance than others from investments in inter-organizational ICT (IOICT) is incomplete. In this paper we posit that integrative practices with suppliers, is the generative mechanism through which the performance effects of ICT are felt. The performance effects are not due to the utilization of inter-organizational ICT per se. In addition, we propose that the combination of inter-organizational ICT and integrative practices is only effective if companies or supply chains experience high levels of *environmental uncertainty*. We define inter-organizational ICT as the information systems and technologies that link different organizations in a supply chain. Supply chain integration is seen as the synergy reached through the integrative practices in the supply chain. The principal aspect of environmental uncertainty that we consider in this paper is demand uncertainty.

A considerable body of research has shown that performance and IOICT can be positively associated (Da Silveira and Cagliano, 2006; Olson and Boyer, 2003; Saeed et al., 2005). However, the question remains how exactly the investment or presence of IOICT affects the performance in a supply chain and why many manufacturers have not reaped the expected performance benefits (Deveraj et al., 2007; Jap and Mohr, 2002; Mukhopadhyay and Kekre, 2002; Rosenzweig, 2009; Rosenzweig and Roth, 2007; Zhu, 2004). There is some confirmation that the positive association can only be reached if integrative practices link IOICT to SC performance (Devaraj et al., 2007; Hill and Scudder, 2002; Paulraj and Chen,

※ This chapter is based on Zhang X., Van Donk, D.P. & Van der Vaart, T.(2010), "Inter-organizational ICT and supply chain performance: a moderated mediation model of integration and uncertainty", Proceedings of 17th International Annual EurOMA Conference, Jun. 2010, Porto, Portugal.

2007b; Power and Singh, 2007; Sanders, 2008; Vickery et al., 2003). At the same time, there is abundant anecdotal evidence, supported by evidence from some case studies (Snider et al., 2009; Welker et al., 2008), that ICT systems do not always result in improved performance. These oppositional views leave a theoretical gap in our understanding of the utilization of ICT to ensure superior supplier performance. This research gap needs to be addressed to develop a fuller understanding of the role of ICT. This paper addresses this gap in literature and contributes to further theory development.

The doubt about the effectiveness of IOICT offers a real dilemma. On the one hand, investing in IOICT seems vital for effective and efficient exchange between organizations. On the other hand, these investments do not automatically lead to performance improvements even if additional investments in integrative practices have been made. Several authors (Choe, 2003; Jean et al., 2008, Rosenzweig, 2009, Welker et al., 2008) suggest that an additional factor – *environmental uncertainty* - could help understand how IOICT can improve performance.

The impact of environmental factors has been investigated in related research focusing on the effectiveness of supply chain integration only – without taking into consideration the role of ICT. This research provides ample evidence that environmental factors such as uncertainty are important in understanding the relationship between supply chain integration and performance (Bozarth et al., 2009, Chen and Paulraj, 2004; Germain et al., 2008; Van der Vaart and Van Donk, 2008). These studies suggest that supply chain practices should match the level of uncertainty to be effective. Germain et al. (2008) for example show that standardization fits best with low demand uncertainty, whereas integration fits high demand uncertainty. A similar result for supply chain integration is found in Rosenzweig (2009). Although research has investigated how IOICT can be linked to performance through integrative practices, so far it has largely ignored an important question – under what circumstances or what level of environmental uncertainty will IOICT be beneficial. We suggest that the above line of thought in supply chain integration with respect to the impact of environmental factors can be extended to the effectiveness of IOICT.

In sum, we argue that IOICT is linked to performance through integrative practices and that IOICT in combination with integrative practices will lead to increased performance if environmental uncertainty is high. High investments in IOICT and associated integrative practices will probably not increase performance if environmental uncertainty is low.

We ground our study on three important theories. First, the resource-based view (RBV) is used to build support for the idea that improvements in performance are not the result of isolated practices or the presence of isolated information systems such as IOICT but stem from *synergies* from specific arrangements of systems and practices that can be construed to be resources. Our second theoretical perspective is the contingency theory, which explains why and how organizations need to adapt their activities and processes to the characteristics of the environment. According to the contingency theory perspective there is no best way to ensure superior performance. When organizations have resources that match the characteristics of the environment, they perform better, while a mismatch leads to failure and poor performance. This study combines RBV and contingency theory perspectives. Information processing theory asserts that organizations will increase their capacities for processing information by implementing information systems in an environment of high uncertainty since such systems and associated processes will be effective if uncertainty is high. Based on these three theories, the paper proposes that IOICT is related to performance through integrative practices **only if** the environmental uncertainty is high. This assertion stands in contrast to prior studies that have not considered the contingent role of environmental uncertainty in investigating the effects of IOICT in managing supplier performance. By studying the mediating role of integrative practices and the moderating role of environmental uncertainty the present study contributes to the literature on the use of IOICT to improve supplier performance.

The novelty of this study lies in its investigation of two important performance effects: it investigates not only how integrative practices can make IOICT effective (the mediation hypothesis), but also under what environmental circumstances utilization of IOICT is effective in improving supplier performance (the moderation hypothesis). We explore these relationships in detail using primary data, following well-established research procedures.

This study makes the following contributions to the theory and literature pertaining to IOICT in a supply chain context. First, we find support for the importance of integrative practices – information sharing and cooperation - in helping to improve performance of IOICT in a supply link. Second, the results of the study suggest that it is not the utilization of integrative practices alone or ICT that improves supplier performance; rather, it is the combined use (i.e. *synergy*) of systems and integrative practices. Third, the results suggest that environmental uncertainty influences the effectiveness of information systems and integrative practices on supplier performance. We add to the current body of knowledge on how and under which specific circumstances IOICT can be an effective resource. The

empirical setting for our investigations is a sample of Chinese manufacturers (suppliers) and their relationship with their principal buyer.

The remainder of this paper is organized as follows. The next section provides the theoretical background for this paper, along with the hypotheses, which are summarized into the conceptual model of this study. Then, we present the methodology of our study. Data analysis and results are presented in section 4, followed by the discussion and interpretation of the empirical results. The last section provides the main conclusions and directions for future research.

4.2 Theoretical background

In this section, the theoretical basis of our research is presented. We begin with a brief summary of the research on the relationships among inter-organizational ICT, supply chain integration and SC performance. Next, the possible influence of uncertainty on these relationships is discussed. Finally, we develop the hypotheses examined in this study and the resulting conceptual model.

4.2.1 Inter-organizational ICT, supply chain integration and SC performance

Supply chain management seeks to create a seamlessly coordinated process between partners in a supply chain to transform inter-firm competition into inter-supply chain competition (Anderson and Katz, 1998). Inter-organizational ICT (IOICT) refers to the information technology and/or information systems for linking and coordinating with external organizations (Handfied and Nichols, 1999; Sun et al., 2009). It allows for deep, rich information to be processed and transmitted very quickly and cost effectively (Bailey and Francis, 2008; McIvor and Humphreys, 2004; Amit and Zott, 2001). Therefore, IOICT's value for supply chain management has been an important topic in the literature (Li et al., 2009; Sanders, 2008). Some studies have investigated its direct effect and show that IOICT can be associated with increased SC performance (Da Silveira and Cagliano, 2006: Olson and Boyer, 2003; Saeed et al., 2005). In order to understand the underlying mechanisms that link IOICT to SC performance or generate IOICT's value, theoretical and empirical work have been undertaken (Zhang et al., 2011).

One of the underlying theoretical frameworks to understand how IOICT influences performance is the resource-based view of the firm (Barney, 1986; 1991). The basic idea of the resource-based view (RBV) of the firm is that firms have resources that provide a

sustainable competitive advantage if these resources are valuable, rare and can be protected against imitation, transfer, or substitution. According to Wade and Holland (2004), the RBV is also valuable to understand the relationship between information systems and performance. They argue that information systems do not generally directly lead to advantage, but interact with other firm assets and capabilities to increase performance (Bharadwaj, 2000; Wade and Hulland, 2004) suggesting that it is the combination of IOICT and other practices that lead to superior performance. In other words, it is argued that the systems or IT infrastructure is generally not the main resource, but it is the capability to generate a better performance by using the IT infrastructure. Such capabilities are anchored in the human resources, procedures and processes of the organization. Reasoning similarly to how performance in an inter-organization setting can be improved, we assert that having IOICT is not enough but using IOICT to enhance organizational practices between suppliers and buyers in the supply chain is the pathway to gaining sustainable advantage.

The above theoretical reasoning regarding the indirect effect of IOICT on performance is strengthened by the inconsistent results in literature with respect to the direct impact of IT on performance (Sanders, 2007, 2008). As argued by Lim et al. (2004), Sriram and Stump (2004) and Subramani (2004); these inconsistencies stem from the conceptualization of key constructs and that many findings rely on organizational factors such as how IT is used within the organizational context, the performance measures used and the type of management practices (Lim et al., 2004; Sriram and Stump, 2004; Subramani, 2004). As a consequence Sanders (2008, p. 350) concludes that "these inconsistencies reflect the complexity of the problem and underscore the need for more in-depth research on the organizational impact of IT and its use within the supply chain framework".

There is some empirical evidence that IOICT improves SC performance indirectly through specific integration activities between partners in a supply chain. Deveraj et al. (2007) found that e-Business capability is not directly associated with operational performance; however, it is mediated by production information integration, which is related to operational performance. They argue that: "firms must develop a capability for customer and supplier integration to realize the benefits of the new e-Business technologies" (Deveraj et al., 2007, p. 1212). Other studies conclude that the capabilities of a company to *apply* IOICT to manage the operational processes and to cooperate with its partners have a positive effect on SC performance while there is no direct impact of IOICT (e.g. Swafford et al., 2008; Lai et al., 2008; Hsu et al., 2008). Further evidence is derived from supply chain management studies

that confirm that the direct effects of IOICT are often realized at the intermediate, process level (Frohlich and Westbrook, 2002; Power and Singh, 2007).

Together, these studies confirm the arguments based on Resource Based View and show that IOICT should be combined with integrative activities in the supply chain to form valuable capabilities (i.e. resources) that help firms to achieve SC performance improvements.

4.2.2 The role of uncertainty in supply chains

According to contingency theory, organizations will adapt their activities and processes to the characteristics of the environment (e.g. Mintzberg, 1979). This theory also points out those firms that match their activities and processes to the contingencies perform better, while a mismatch or a slow response to changes leads to failure and poor performance (Miles and Snow, 1974). Consequently, there is no universal set of choices that is optimal for all businesses (Gingsberg and Venkatraman, 1985).

In line with these ideas, the information processing theory, as originally proposed by Galbraith (1974), asserts that an organization needs to adapt its information processing capabilities with the level of uncertainty. Further, information processing theory states that organizations should consider what the implications for information processing are, that stem from environmental conditions (e.g. demand uncertainty) and organizational design features (Egelhoff, 1991). One common way of increasing processing capabilities is the use of ICT and the redesign of associated processes. So from the perspective of information processing theory, it follows that if uncertainty is high, ICT and associated processes will be more effective depending on how well they fit the environmental circumstances. Therefore, it is logical that the inter-organizational ICT usage and integration should fit the circumstances challenging the belief that IOICT and integrative practices can be effective regardless of environmental uncertainty. Related to these arguments, Wade and Hulland (2004) propose that boundary spanning resources (such as IOICT and SC practices) will be related to performance, if the environment has a high level of complexity.

The notion that environmental uncertainty has an impact on the effectiveness of ICT and associated processes has been mentioned in the SCM literature. Most of that literature tends to be qualitative or conceptual in nature. Fisher (1997) indicates that the root cause of the problems plaguing many supply chains is a mismatch between the type of environmental uncertainty and the SC strategy. Recently, several authors (Chen and Paulraj, 2004; De Leeuw and Fransoo, 2009; Van der Vaart and Van Donk, 2008) include environmental uncertainty

into their conceptual models. They indicate that environmental uncertainty does affect the relationships between SC management factors and SC performance, which is recently also empirically confirmed by Wong et al. (2011).

In a number of conceptual contributions within the ICT literature it is assumed that uncertainty plays a moderating role in the relationship between ICT and performance (Jean et al., 2008; Melville et al., 2004; Melville and Ramirez, 2008). These papers suggest that environmental uncertainty influences the relationship between ICT, business processes and organizational performance.

Although, the above discussion provides the theoretical foundation and arguments that support the moderating role of uncertainty, both in the field of ICT as well as in the field of SCM, a clear recognition and empirical validation of that role is missing in the literature. Therefore, the main thrust of this paper is to address the impact of uncertainty on the effectiveness of IOICT and integrative practices in the supply chain.

4.2.3 Hypotheses and Conceptual model

In this section, we develop our hypotheses based on the theoretical background and the discussion in the previous section. We summarize our hypotheses at the end of this section into a conceptual model.

The relationships between IOICT, supply chain integration and supplier performance

While two of our core concepts (IOICT and supplier performance) are relatively well-understood, supply chain integration is less so. Supply chain integration in existing literature involves different activities between a focal firm and its suppliers and/or customers (Williamson, 2008). Supply chain management and integration have been captured and measured in many different ways. Recently, it has been proposed that supply chain integration consists of various variables or dimensions (e.g. Das et al., 2006; Flynn et al., 2009). Information sharing and cooperation are generally considered to be key dimensions or elements of supply chain integration (e.g. Li et al., 2010a; Van der Vaart and Van Donk, 2008, Wong et al., 2011). Both are also specifically important in realizing the benefits of IOICT. According to Johnston et al. (2004) cooperation in a relationship refers to integration of decision making between supply chain partners. Important aspects are: joint responsibility and willingness to diverge from fixed contractual terms as conditions change. Li et al. (2010b, p.335) also refer to cooperation as being important in the context of problem-solving in inter-

firm relationships. Joint problem solving and inter-firm cooperation will help in acquiring new knowledge and capabilities from partners (e.g. Dyer and Nobeoka, 2000). Such capabilities will also relate to the use of IOICT. Cooperation implies a partnership relationship based on a joint problem-solving capability (Goffin et al., 2006), which forms the base for competitive advantage. Cooperation can also be associated with openness in communication and information exchange (Chen and Paulraj, 2004) and symmetry in the relationship (McCarter and Northcraft, 2007). It is clear that openness in communication and information exchange will imply a more effective use of IOICT.

Starting from both the RBV and the information processing perspective, we argue that cooperation will increase the capability of using IOICT in joint decision making efforts and increase the information processing capability. IOICT and cooperation both help to increase information sharing between partners. This reasoning and the above mentioned studies motivate our focus on the mediating role of information sharing and cooperation in the relationship between IOICT and supplier performance. As mentioned above, our sample focuses on suppliers and their relationship with their key buyers. Therefore, we focus on *supplier performance* in that relationship as the outcome variable of interest.

IOICT has increasingly become important for enhancing SC performance (Handfield and Nichols, 1999). Previous studies have provided evidence that IOICT and SC performance can be positively associated (Da Silveira and Cagliano, 2006; Lai et al., 2008). From our theoretical discussion above, research has also shown that IOICT improves supplier performance through a higher level of information sharing (Cagliano et al., 2006; Devaraj et al., 2007) and cooperation (Heim and Peng, 2010; Tan et al., 2010; Zhu et al., 2010). Remarkably, most studies test either direct or indirect paths (but not both) between IOICT and SC performance. An exception is Sanders (2007), who confirms both a direct and indirect relationship between e-business technology and SC performance. In this paper we follow the recommendation of Sanders (2007) and employ a model incorporating both the direct and indirect effects of IOICT on supplier performance as a starting point. We propose the following hypotheses:

H1: IOICT has a direct and positive impact on supplier performance.

H2a: Information sharing mediates the positive relationship between IOICT and supplier performance.

H2b: Cooperation mediates the positive relationships between IOICT and supplier performance.

Our study builds on Sanders (2007), but is distinctly different in three ways. First, as an extension to Sanders' work, we include two integrative practices (cooperation and information sharing) in our model. Instead of examining the complex interactions between intra- and inter-organizational collaborative practices, we aim to better understand the role of inter-organizational practices through a more detailed representation. Second, we use more concrete measures for IOICT in terms of use of internet, extranet, and e-mail. Again, this choice is motivated by the need to understand the relationship between IOICT, integrative practices and supplier performance in greater detail. Third, a principal objective of this study is to include the effect of environmental uncertainty on the anticipated relationships among IOICT, cooperation, information sharing and supplier performance. The above hypotheses are a first step to achieve that aim.

As indicated before, we capture two dimensions of supply chain integration in our model: *information sharing* and *cooperation*. We already pointed out that the positive effect of coordination and information sharing. Li and Lin (2006) show that a higher level of inter-firm relationship implies a higher level of information sharing in a supply chain. A higher level of inter-firm cooperation can generally be associated with a partnership type of relation (Jap, 1999; Johnston et al., 2004). In the absence of partnerships, firms will be reluctant to share information with their supply chain partners (McCarter and Northcraft, 2007). Therefore, we expect that more cooperation will lead to more information sharing as stated in the next hypothesis:

H3: There is a direct positive relationship between inter-organizational cooperation and information sharing.

Moderating effects of uncertainty on the mediated relationship

There are different sources of environmental uncertainty in supply chains. Chen and Paulraj (2004) distinguish between three possible sources of SC uncertainty: demand, supply, and technology uncertainty. Demand uncertainty is experienced by almost every firm (Paulraj and Chen, 2007a) and is a major contributor to overall uncertainty according to Davis (1993) and Chen et al. (2000). Therefore, in this paper we focus on demand uncertainty. Next, we discuss the research hypotheses and the influence of demand uncertainty in the conceptual model.

Demand uncertainty is closely related to how difficult it is to predict the demand of a product (e.g. Sun et al., 2009). In the context of high demand uncertainty, the sales volume and product mix are more difficult to monitor and to predict than in the context of low demand uncertainty (Celly and Frazier, 1996). Both the contingency theory and the information processing theory predict that companies will have more benefits from ICT (and IOICT) and associated organizational processes if uncertainty is high. Integration makes companies aware of how their mutual processes affect each other. It allows firms to create joint forecasts, which are more accurate than individual functions' forecasts (Germain et al., 2008). Increased unpredictability of demand will motivate organizations to share information with their supply chain partners in order to respond to frequently changing needs of customers (Van Hoek, 2001; Zhao et al., 2002). Meanwhile, strong buyer-supplier relationships that support interaction and cooperation are needed for organizations to frequently make the necessary adjustments (Wong and Boon-itt, 2008). Specifically, cooperation can be associated with the willingness to adapt and modify agreements in the light of unforeseen events and to be jointly responsible for problems due to uncertainty (Johnston et al., 2004). In other words, if uncertainty is high cooperation is likely to increase the organizational capability of making IOICT more effective through enabling open, inter-organizational decision-making. In contrast, under conditions of stable demand or low uncertainty in which buyers' preferences and needs do not change as much, products are labeled as functional (Fisher, 1997). That requires little adjustment, and therefore a relatively low level of communication and information sharing between buyer and supplier is sufficient. In this situation, the partnership can be associated with arm's length exchange and consequently trading partners make their decisions more independently rather than engaging in joint decision-making. In other words, cooperation is not likely to have much influence on supplier performance. In sum, information sharing and cooperation will have a stronger positive influence on supplier performance under high demand uncertainty than under low demand uncertainty.

Earlier studies that focus on supply chain practices and integration have revealed similar phenomena. Fynes et al. (2004) confirm that the higher the level of demand uncertainty, the stronger the relationship between SC relationship quality (using indicators of trust, adaption, communication and co-operation) and performance. Recently, Germain et al. (2008) show that the positive association of internal integration with SC performance only exists when demand uncertainty is high, while there is no association in the context of low demand uncertainty. In yet another study, Kim et al. (2006) empirically show that demand uncertainty is one of the contextual factors that give rise to information processing needs. In addition, they showed that the degree of electronic information transfer should fit the supply chain

context, such as demand uncertainty and channel interdependence. Boyle et al. (2008) indicate that e-commerce may become increasingly important especially in an uncertain environment. The above results confirm the importance of uncertainty and its effect on supply chain practices and the use of information technology.

Based on our earlier theoretical arguments with respect to the role of IOICT and the empirical evidence mentioned above, it can be argued that high uncertainty will strengthen the role of supply chain integration as a mediator of IOICT on supplier performance. In other words, we expect that under high demand uncertainty (1) information sharing and cooperation will be more effective to improve supplier performance, and (2) the relationship between inter-organizational ICT and supplier performance via supply chain integration also becomes stronger. Thus, we propose the following hypotheses:

H4a: Demand uncertainty will moderate the strength of the mediated relationship between IOICT and supplier performance via information sharing, such that the mediated relationship will be stronger under high demand uncertainty than under low demand uncertainty.

H4b: Demand uncertainty will moderate the strength of the mediated relationship between IOICT and supplier performance via cooperation, such that the mediated relationship will be stronger under high demand uncertainty than under low demand uncertainty.

The effect of uncertainty on the effectiveness of inter-organizational ICT

In the previous subsection we have discussed how demand uncertainty moderates the influence of inter-organizational ICT on supplier performance via supply chain integration. As our paper seeks to investigate the influence of demand uncertainty on both the direct and indirect - or mediated - relationship between IOICT and supplier performance, the final issue of research interest is to explore the effect of demand uncertainty on the direct relationship between IOICT and supplier performance.

In the context of high uncertainty, the information exchanged by supply chain partners can easily become outdated. In contrast, when demand is predictable, the supplying firms typically produce and deliver standard products, labeled as functional that have been made-to-stock (Fisher, 1997). Information shared can be largely stable and formalized because it relates to standard products (Welker et al., 2008). As a result, in the face of predictability the goal is to design a system for maximum efficiency, rather than flexibility as would be needed

in the face of unpredictability (Fisher, 1997). Iyer et al. (2009) demonstrate that inter-organizational ICT is more an efficiency mechanism than a flexibility mechanism, and show it is less effective for supply chain improvement in a chaotic and unpredictable environment than in a stable and predictable one. Based on the above discussion, we hypothesize:

H5: Demand uncertainty moderates the relationship between IOICT and supplier performance. More specifically, the relationship will be stronger under low demand uncertainty than under high demand uncertainty.

It should be noted that validation of this hypothesis would add predictive validity to the proposed model. The negative moderating effect of uncertainty as stated in Hypothesis 5 seems to contradict the positive moderating effect of uncertainty as stated in Hypotheses 4a/b. Therefore, the logic of these two hypotheses deserves further clarification. The idea is that for companies that experience low levels of uncertainty, inter-organizational ICT will be directly beneficial, without a need for high integration levels. As explained, the IOICT is used as an efficiency mechanism and it does not enable advanced integrative practices. Under high levels of uncertainty we expect IOICT to be more effective in combination with higher levels of information sharing and cooperation: the two key aspects of supply chain integration. In fact, we suggest that these differential effects on the direct and indirect effects under different levels of uncertainty might be the principal reason for the previously discussed inconsistent findings in prior research.

Summary and conceptual model

In Figure 4.1 we summarize the formulated hypotheses. The figure presents the expected relationships between IOICT, information sharing, cooperation and supplier performance, and the expected influence of demand uncertainty.

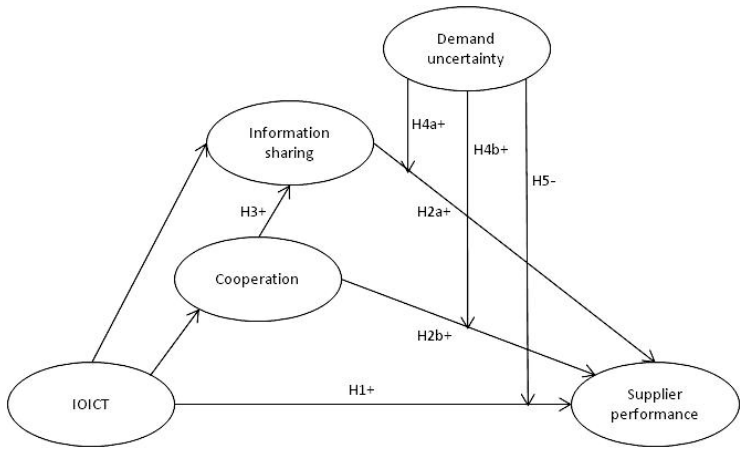

Figure 4.1 The conceptual model

4.3 Methodology

In this section, we discuss the development of the questionnaire, the data collection, the resulting sample and the data analysis.

4.3.1 Questionnaire development

Measures for different constructs in this study were mainly derived from earlier work in the fields of SCM and ICT. Inter-organizational ICT was measured using items from Li and Lin (2006) and Saeed et al. (2005). We excluded EDI in our measurement, as it appears that due to the fact that Chinese companies started large scale ICT implementation a decade later than companies in the Western part of the world, they bypassed traditional EDI and directly moved to contemporary ICT solutions based on internet and extranet. Internet was chosen as being open access, while extranet represents the extension of a private network onto the Internet with special provisions for authentication, authorization and accounting. In other words, Extranet can be considered as a replacement or equivalent of EDI. The items used for measuring information sharing by the buyer are adapted from De Toni and Nassimbeni (2000), Frohlich and Westbrook (2001), and Giménez and Ventura (2003). The selected items relate to the extent to which the buyer communicates sales forecasts and (changes in) production plans to the supplier.

For cooperation we relied on the items from Johnston et al. (2004), which reflect how supply chain partners integrate decision making. Important aspects are joint responsibility and willingness to diverge from fixed contractual terms as conditions change. As our target population is suppliers, we focus on how well the supplier satisfies the buyer's requirements. Supplier performance was measured by four items reflecting the buyer's satisfaction with respect to the order quantities, special requirements, delivery lead times and delivery reliability. The main reason for the focus on service aspects of performance is that ICT fosters capabilities for quick response and flexibility to deal with changes in market conditions (Goh et al., 2007a). The items used to measure supplier performance were adapted from Giménez and Ventura (2003). Four items adapted from Chen and Paulraj (2004) were used to measure demand uncertainty. All the items were measured with a five-point Likert scale.

The original questionnaire in English was translated into Chinese and translated back into English separately by three different academics in Operations Management. Subsequently, an expert in the operation field was asked to compare these three English questionnaires to make sure that in the translation process the content of English and Chinese versions were not altered. In the pre-pilot study, the questionnaire was reviewed by five academics and evaluated through structured interviews with six executives for readability and ambiguity. They were asked to comment on the clarity and expression of the items in order to make sure that no further changes were needed.

4.3.2 Sample and data gathering

Recently, there have been a number of studies (Flynn et al., 2010; Jiang et al., 2009; Li et al., 2009), mostly co-authored by Chinese researchers investigating contemporary SC issues in Chinese companies. These studies represent the increased interest in and importance of China and Chinese manufacturing firms as being the manufacturers of the world. The present study adds to our knowledge of this important country and its manufacturing sector. Moreover, given the current position of Chinese manufacturing, we think the present study yields generalizable results. Another reason for gathering data in China was convenience, as one of the authors is based in China. This guaranteed better access to organizations and a high response rate. To further assure a high response, we choose to work with two institutions that provided access to companies. The two institutions were the China IT promotion institution and the Zhejiang Province enterprise association. The China IT promotion institution aims to promote ICT application in industry. It is an intermediary between the government and the companies, as well as between ICT-providers and industries. Its membership includes nation-

wide manufacturing firms in China. Zhejiang Province is one of the largest industrial areas in China. An important manufacturing association in this province is the Zhejiang Province enterprise association. The member lists of these two institutions were the starting population for our study. As this study is aimed at industrial suppliers, the first step was to determine whether the companies in this population were indeed industrial suppliers. That resulted in 278 companies from the China IT promotion institution and 386 companies from the Zhejiang Province enterprise association.

Following Phillips (1981), the survey aimed for high ranking respondents as they tend to be more reliable as a source of information than lower ranked respondents. Therefore, we asked the questionnaires to be filled out by the supply chain manager, chief information officer or a top level executive. The respondents were required to fill out the questionnaire with respect to their most important buyer (i.e. customer). The data gathering was carried out in several steps. We distributed the paper version at the annual conference of the China IT promotion institution, making sure that the person attending the conference was a suitable key informant for their firm. If not, the questionnaire was mailed to a key informant. For the target companies of the Zhejiang province enterprise association, the printed version was mailed to the companies directly. The above two steps were executed at the same time. Responses from the conference were received first. Non-respondents were sent a reminder together with the electronic version of the survey. Data collection took place from December 2007 to April 2008. During the conference, we distributed 152 questionnaires and got 124 responses (response rate of 81.6%). An additional 43 companies responded from the 126 remaining target companies of the China IT promotion institution (response rate of 34.1%). The response from the Zhejiang Province enterprise association was 44.5% (172 returns from the 386 questionnaires sent).

Our final sample contained 320 respondents for an overall response rate of 48.2% (320 out of 664). Table 4.1 shows the distribution of respondents across functions. The distribution of the SIC codes is provided in Table 4.2.

Table 4.1 Respondents

The respondent position	Number	Percent
President/Vice President	54	16.8
Supply chain Manager	99	30.8
Chief Information Officer	96	29.9
Director	67	20.9
Others	4	1.6
Total	320	100

Table 4.2 Industry classification

Two-digit SIC	Number	Percent
20. Food and kindred products	21	6.6
22. Textile mill products	47	14.7
23. Apparel and other product made from fabrics and similar	32	10
25. Furniture and fixtures	8	2.5
26. Papers and allied products	13	4.1
27. Printing, publishing and allied industries	7	2.2
28. Chemicals and allied products	29	9.1
29. Petroleum refining and related products	21	6.6
30. Rubber and miscellaneous plastics products	24	7.5
32. Stone, clay, glass, and concrete products	3	0.9
33. Primary metal industries	9	2.8
34. Fabricated metal products except machinery and transportation equipment	17	5.3
35. Industrial, commercial machinery and computer equipment	23	7.2
36. Electronic, other electrical equipment and components, except computer equipment	31	9.7
37. Transport equipment	15	4.7
38. Measuring, analyzing, and controlling instruments; Photographic, medical, and optical goods, etc.	11	3.4
39. Miscellaneous manufacturing industries	9	2.8
Total	320	100

Data analysis and hypotheses testing

The data were examined for non-response bias by exploring differences between early and late respondents (Armstrong and Overton, 1977). Using one-way ANOVA ($p>0.05$) no significant differences could be detected for the means of a number of important control variables such as annual sales revenues, number of employees and the unit selling price of the primary product.

To examine the possibility of common method variance (CMV) we followed Podsakoff and Organ (1986). We used Amos 7.0 to do a confirmatory factor analysis (CFA). First, we linked all the items of the five factors to one single factor to perform Harman's one factor test. Results of this one-factor model were χ^2/df=9.53, CFI=0.50; GFI=0.70; RMSEA=0.17, IFI=0.51, which displayed a poor model fit. Then we compared this one-factor model with the five-factor model. The five-factor model showed a much better model fit (χ^2/df=2.03, GFI=0.92; CFI=0.92; RMSEA=0.06, IFI=0.95). These results indicate that the respondents could distinguish the measurement constructs very well and that CMV was not a concern. In further analysis, factor means and inter-factor correlations were determined. The reliability of the underlying factors was assessed in terms of Cronbach's alphas. Finally, CFA was

performed to check whether the items met the criteria for convergent and discriminant validity, as well as construct reliability. These results are presented in the next section.

To simultaneously estimate multiple relationships between latent constructs, AMOS 7.0 was used to analyze the data and test the research hypotheses and resulting conceptual model. First, mediation was analyzed, following the procedure suggested by Venkatraman (1989). Second, to investigate the moderating effect of demand uncertainty a two-group analysis in structural equation modeling (SEM) was used (Arbuckle, 2007). The mean of the four items of demand uncertainty was taken and the sample was then split into three groups according to the median of the composite score. This led to 101 observations in the "high demand uncertainty" group (value is higher than 3), 141 observations in the "low demand uncertainty" group (value is lower than 3) and 78 observations in the middle group (value is equal as 3). We compared the "high" versus "low" groups and discarded the middle group in further analysis (comparable to Frohlich and Westbrook, 2002). A one-way ANOVA test showed that there were no significant differences between the group means for the number of employees ($p>0.05$), and annual sales ($p>0.05$).

4.4 Results

Our results are discussed in two sections. First, we present the results of our data analysis. Second, we present the results pertaining to the mediation and moderation hypotheses.

4.4.1 Measure validation and reliability

The scale items, Cronbach's alphas, the resulting CFA with loadings, AVE and CR are summarized in Table 4.3. Most Cronbach's alphas equal or exceed the widely accepted cutoff value of 0.70 (Nunnally and Bernstein, 1994), while the value of supplier performance (.62) is greater than the minimum recommended value of .60 (Hair et al., 2009).

In the overall CFA, the χ^2 to degree of freedom ratio is 2.08 ($p<.001$), which is within the recommended range of 3 to 1 (Marsh and Hocevar, 1985). Furthermore, we used four additional fit indexes: the goodness of fit index (GFI), the root mean squared error of approximation (RMSEA), the comparative fit index (CFI), and the incremental fit index (IFI). All these indices show that our five-factor measurement model fits the data adequately (GFI=0.92, RMSEA=0.06, CFI=0.92, IFI=0.95) (Chen et al., 2008)

Table 4.3 CFA results for measurements scales and associated indicators

Constructs and associates indicators	Std. Loading
F1: Inter-organizational ICT: Cronbach's α =.76, CR=.76, AVE=.53	
Please indicate to what extent these technologies are used in your company: [a]	
Use electronic mail with the key buyer	.60
Have an internet connection with the key buyer	.93
Have an extranet connection with the key buyer	.61
F2: information sharing by buyer: Cronbach's α =.85, CR=.86, AVE=.68	
Please indicate the degree to which you agree with each statement: [b]	
Receive information about changes in the production plans of our key buyer at once.	.82
Receive information about the sales forecasts from our key buyer	.89
Receive information about the production plans of our key buyer.	.75
F3: Cooperation: Cronbach's α =.87, CR=.84, AVE=.64	
Please indicate the degree to which you agree with each statement: [b]	
The parties would rather work out a new deal than to hold each other to the original terms	.86
The parties will be open to modifying their agreement if unexpected events occur	.81
Problems that arise in the course of this relationship are treated as joint rather than individual responsibilities.	.85
F4: Supplier performance: Cronbach's α =.62, CR=.82, AVE=.54	
Provide an indication of the improvement of your organization's performance relative to three years ago. In case the relationship with your key buyer is shorter than three years, please refer to the improvement of your performance since the start of the relationship: [c]	
Responds to the special requirements of the key buyer	0.47
Notifies the key buyer in advance about late deliveries or stock-outs	0.72
Provides the quantities ordered by the key buyer	0.40
Has a short delivery lead time	0.53
F5: Demand uncertainty: Cronbach's α =.70, CR=.90, AVE=0.69	
Provide an indicate the degree to which you agree with each statement with regard to your key buyers: [b]	
The total volume of products delivered to the key buyer fluctuates drastically from week to week	0.88
The mix of products delivered to the key buyer change considerably from week to week	0.94
The total buying volume of products delivered to the key buyer is difficult to predict	0.68
The required mix of products delivered to the key buyer is difficult to predict	0.95

[a] Scale: no use -significant use (1-5)
[b] Scale: totally disagreed - totally agreed (1-5)
[c] Scale: far worse - far better (1-5)

All items loaded significantly on their corresponding latent construct at the .001 level, indicating that the constructs were appropriately reflected by their indicators. Further, the average variance extracted (AVE) ranged from 0.53 to 0.69, surpassing the 0.50 threshold (Bagozzi and Yi, 1988) showing sufficient convergent validity. We assessed discriminant

validity by comparing the AVE with the squared correlations between constructs. The squared correlation between constructs was lower than the AVE for each of the constructs, which indicates that the constructs have sufficient discriminant validity. As a final step to assess the unidimensionality of each construct, we calculated composite reliabilities (CR). All CR's ranged from 0.62 to 0.90, which are well above the generally acceptable level of 0.60 (Nunnally and Bernstein, 1994). Having satisfied all these tests, we feel confident that the measurement model demonstrates reliability, discriminant validity and convergent validity.

In addition, testing of the measurement model without demand uncertainty was conducted using 2-group CFA (low and high uncertainty). In the initial 2-group CFA, factor loadings were estimated freely across groups. The loadings were then declared invariant or equal across groups. The difference in χ^2 between the two models is not significant ($\Delta\chi^2$= 9; Δd.f. = 5.23; p>0.10). This means that *no asymmetries exist in the loadings* across the two groups, thus the loadings can be modeled as equal across the two groups in all subsequent analyses. This result indicates *measurement equality* which facilitates maximum likelihood estimation in multi-group structural equations modeling (SEM) (Hair et al., 2009). The results of the two-group CFA provide fit indices of χ^2/df=1.63 (p<0.001), CFI=0.94, GFI=0.90, RMSEA=0.05, CFI=0.94, IFI=0.94, which suggest a good fit of the two-group CFA model.

The means, standard deviations and inter-factor correlation for the constructs are shown in Table 4.4. All correlations between Inter-organizational ICT, information sharing by buyer, cooperation and supplier performance are significant at the p<0.01 level. None of these constructs correlate with demand uncertainty.

Table 4.4 Means, standard deviations, and correlation matrix

Construct	Mean	SD	1	2	3	4	5
1. Inter-organizational ICT	3.05	.87					
2. Information sharing by buyer	2.70	.93	.51**				
3. Cooperation	3.05	.91	.33**	.54**			
4. Supplier Performance	4.03	.42	.17**	.20**	.20**		
5. Demand Uncertainty	2.85	.72	.-10	-.09	-.05	.029	---

** Correlation is significant at the .01 level (2-tailed).

4.4.2 Hypotheses testing

First, we tested the conceptual model and examined mediation (Hypothesis 2a and 2b) using the entire data set in SEM. Then, we used the two-group analysis to estimate the moderating role of demand uncertainty.

Conceptual Model

The overall model fit indices (χ^2/df=1.82 (p<0.001), CFI=.95, GFI=.97, RMSEA=.05, IFI=.97) are well within the range recommended by Browne and Cudeck (1993) and suggest sufficient support for our conceptual model. It can thus serve as the basis for evaluation of our hypotheses. The results indicate that more IOICT usage leads to both more information sharing (β=0.48, p<0.001) and cooperation (β=0.43, p<0.001) between partners in a supply chain. Further, more information sharing by the buyer improves supplier performance (β=0.35, p<0.001). However, cooperation has no direct significant effect on supplier performance (β=0.09, p>0.05). Further, there is a significant, positive relationship between information sharing and cooperation (β=0.36, p<0.001), which supports hypothesis H3. Our analysis does not find a significant direct effect of IOICT on supplier performance (β=0.02, p>0.05) in the presence of cooperation and information sharing; therefore hypothesis H1 is not supported. The results are summarized in Figure 4.2.

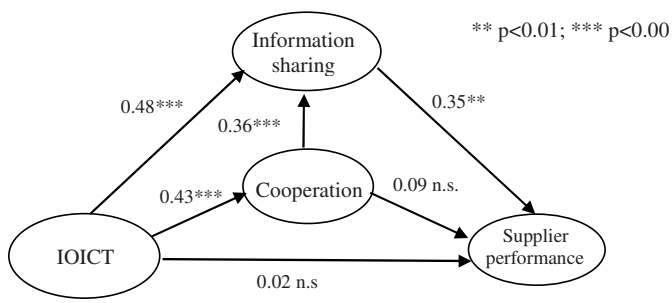

Figure 4.2: The structural model

Mediation analysis

To assess the mediation effect of information sharing and cooperation on the relationship between inter-organizational ICT, three alternative models were estimated following Venkatraman (1989). First, in Model 1 (the direct model) only the direct effect of IOICT on supplier performance was estimated. Second, in Model 2 (the partial mediating model) the indirect effects of IOICT on supplier performance via information sharing and cooperation were considered in addition to Model 1. Finally, in Model 3 (the full mediation model) only

the indirect paths were considered, by removing the direct relationship from Model 2. Table 4.5 summarizes the path coefficients and goodness of fit statistics of the all models.

Table 4.5 Result of structural equation modeling of competing models

	Conceptual Model	Direct model (Model 1)	Partial mediation Model (Model 2)	Full mediation Model (Model 3)
Paths in structural model				
IOICT → Information sharing by buyer	0.48***	----	0.67***	0.67***
Information sharing by buyer → Supplier performance	0.35**	----	0.34**	0.35***
IOICT → Cooperation	0.43***	----	0.48***	0.48***
Cooperation → Supplier performance	0.09		0.11	0.11
IOICT → Supplier performance	0.02	0.29***	0.02	----
Information sharing by buyer → Cooperation	0.36***	----	----	----
Model fit statistics				
χ^2/ df	1.82	3.00	2.42	2.38
GFI	0.97	0.96	0.94	0.94
CFI	0.95	0.94	0.95	0.95
RMSEA	0.05	0.08	0.07	0.07
IFI	0.97	0.94	0.95	0.95
Supplier performance	0.17	0.09	0.16	0.16

** p<0.01; *** p<0.001.

According to Baron and Kenny (1986), four conditions are necessary to establish mediation. First, the results show that IOICT and supplier performance are significantly related (β=0.29, p<0.001, Model 1). Moreover, the results of Model 2 indicate that both the effects of IOICT on information sharing by the buyer (β=0.67, p<0.001) and the effect of information sharing on supplier performance (β=0.34, p<0.001) are positive and significant. However, although there is a significant relationship between IOICT and cooperation (β=0.48, p<0.001), the results show that there is no significant relationship between cooperation and supplier performance (β=0.11, p>0.05). The conclusion based on a comparison of the results of Model 1 and Model 2 is that if information sharing and cooperation are included in the model, the relationship between IOICT and supplier performance is no longer significant. This shows that with regard to information sharing the four conditions are fulfilled, which supports hypothesis H2a. However, because there is no significant relationship between cooperation and supplier performance, H2b is not supported. We conclude based on our

sample that the impact of IOICT on supplier performance is only mediated by information sharing by the buyer and not by cooperation.

Furthermore, based on a comparison of the model fit indices shown in Table 4.5, the conceptual model has better fit indices than models 1-3 in which the link between cooperation and information sharing was left out to sharply focus on the *mediation* effects of integration practices. It indicates that there exists a relationship between information sharing and cooperation which needs to be recognized.

Moderation analysis

To investigate the moderating role of demand uncertainty, we carried out a two-group analysis based on Model 2. The fit statistics for the two-group analysis based on the split in demand uncertainty are: χ^2/df=1.79 ($p<0.001$), CFI=.93, GFI=.89, RMSEA=.06, IFI=.93. The path between information sharing by the buyer and supplier performance is positive and significant if demand uncertainty is high ($\beta_{11}=0.90$; $p<0.01$), and not significant if demand uncertainty is low ($\beta_{12}=0.25$; $p>0.05$). Furthermore, a single degree of freedom $\Delta\chi^2$-test that compares the model to a nested one with β_{11} equaled to β_{12}, is significant ($\Delta\chi^2=5.53$; $\Delta df=1$; $p<0.05$). This result confirms that demand uncertainty moderates the positive effect of IOICT on supplier performance. The path between cooperation and supplier performance is not significant in the context of both low and high demand uncertainty. The result of the $\Delta\chi^2$-test (to compare the model to a nested model in which the two paths are constrained) is not significant ($\Delta\chi^2=1.07$; $\Delta df=1$; $p>0.05$). Therefore, Hypothesis 4b is not supported.

The above analysis confirms that information sharing by the buyer mediates the impact of IOICT on supplier performance and that the mediation effect differs between low and high levels of demand uncertainty. According to Muller et al. (2005), moderated mediation is found when there is an unmoderated overall treatment effect, but the indirect effect of the treatment via the mediator is moderated (Muller et al., 2005, p. 856). Therefore, in addition we conducted a two-group analysis based on Model 1. The result of the $\Delta\chi^2$-test is not significant ($\Delta\chi^2=1.07$; $\Delta df=.001$; $p>0.05$). This confirms that there is an unmoderated overall treatment effect; only the indirect effect of the treatment via information sharing is moderated. Therefore, we feel safe in concluding that Hypothesis 4a is confirmed.

With regard to the direct path between IOICT and supplier performance, the relationship is not significant both under high demand uncertainty ($\beta_{31}=-.45$; $p>0.05$) and under low uncertainty ($\beta_{32}=.19$; $p>0.05$). However, the $\Delta\chi^2$-test shows that there is a significant

difference between the two groups ($\Delta\chi^2$=1.07; Δdf=5.96; p<0.05). Therefore, demand uncertainty moderates the relationship between IOICT and supplier performance and so Hypothesis 5 is confirmed.

Table 4.6 Result of 2-group analysis

	Low subgroup	High subgroup	$\Delta\chi^2$ test	Moderator
Paths in structural model				
IOICT → information sharing by buyer	0.66***	0.79***	$\Delta\chi^2(1)$=0.85 p>0.05	No
information sharing by buyer → supplier performance	0.25	0.90**	$\Delta\chi^2(1)$=5.53; p<0.05	Yes
IOICT → Cooperation	0.59***	0.55***	$\Delta\chi^2(1)$=2.35; p>0.05	No
Cooperation → supplier performance	0.09	0.17	$\Delta\chi^2(1)$=0.62; p>0.05	No
IOICT → supplier performance	0.19	-0.45	$\Delta\chi^2(1)$=5.96; p<0.05	Yes

** p<0.01; *** p<0.001.

4.5 Discussion of results

This paper contributes to knowledge about how firms can use IOICT to their benefit. The results show that cooperation and information sharing are the generative mechanisms through which IOICT's effect on supplier performance is realized. This is especially true if demand uncertainty in the buyer-supplier link is high. Overall, the results are in line with the hypotheses.

Two themes stand out for further discussion as some of the results deviate from our expectations. First, we discuss the mediating role of supply chain practices in making IOICT effective. More specifically, we address the role of cooperation; contrary to our hypothesis, this variable does not mediate the effect of IOICT, but does have a positive effect through information sharing. Secondly, we address the role of uncertainty in greater detail. Particularly, we have a closer look at the findings with respect to both the direct and indirect impact of IOICT under the conditions of low and high demand uncertainty.

Making IOICT effective: the mediating role of supply chain practices

Both elements of supply chain integration - information sharing by the buyer and cooperation – were expected to have a positive and direct effect on supplier performance. However, we

did not find such an effect for cooperation, in contrast to previous research (e.g. Klein et al., 2007; Tan et al., 2010). In addition, no moderation effects were detected for the mediated relationship between cooperation and supplier performance. The most plausible explanation can be found in the positive relationship between information sharing and cooperation. This positive relationship suggests that cooperation may not improve supplier performance directly, but does so via information sharing by the buyer. Cooperation is associated with the intention to jointly improve supplier performance and with an open, flexible decision-making and problem solving process. Apparently, this stimulates the sharing of information by the buyer. Information sharing by the buyer in turn improves supplier performance. These results confirm that IOICT improves performance indirectly through its mediated effect on supply chain practices. An additional perspective is that in a context that needs high levels of information processing, the infrastructure (IOICT) is not helpful by itself. In order to make IOICT effective, organizations have to develop specific organizational resources. These relate to integration in decision making between supply chain partners and openness in information exchange to be able to react to environmental uncertainty. In other words, both infrastructure (IOICT) and the capability of joint decision making enable information sharing, and information sharing drives performance.

Our findings might also add to a better understanding of the different dimensions of supply chain integration (Das et al., 2006). The results show that some dimensions of supply chain integration might have a direct effect on performance, while other dimensions only have an indirect effect, but may be foundational. That idea seems to be confirmed by Peck and Jüttner (2000) who indicate that management has come to see supply chain cooperation as an important part of its strategy. Such strategic behavior needs to be translated into performance through execution (Mankins and Steele, 2005), such as information sharing. These results illustrate the *central role of information sharing*. As Simatupang and Sridharan (2008, p. 407) state: “information sharing serves as the glue that combines other elements of integration into a whole”. The results also provide support for the viewpoints of the RBV, that is, that the improvement of performance is a result of information technology enhancing organizational capabilities (i.e., ability to share timely information with suppliers which increases supply chain visibility) and business processes (such as collaborative planning of production and schedules, and joint problem solving).

The role of uncertainty

As indicated above, the main thrust of this paper is that contingencies such as demand uncertainties influence the effectiveness of IOICT and supply chain practices. In line with this idea, our study challenges previous research (e.g. Rai et al., 2006; Sanders, 2008) that stated that more information sharing will always lead to better performance. The results also challenge the idea that implementing ICT will result in better performance in all circumstances. At least, for IOICT we show that specifically if demand uncertainty is high, IOICT is positively associated with increased performance via supply chain practices. More specifically, information sharing by the buyer significantly improves supplier performance when demand uncertainty is high. Our study confirms empirically the importance of context and contingencies. This has been advocated in conceptual papers (e.g. Ho et al., 2002; Sousa and Voss, 2008). As such, this study contributes to the understanding of supply chain management and supply chain integration. Particularly, our findings are novel to the extent that we study the role of IOICT vis-à-vis supply chain integration practices.

In order to better understand if and how IOICT helps improve performance, we tested both for *direct* and *indirect* effects of IOICT. We find that the indirect effect of IOICT is significant and the direct one is not on supplier performance. However, although the direct effect is insignificant (in all models) there is a significant moderation effect of demand uncertainty on the relationship between IOICT and supplier performance. That is, the insignificant positive effect for low demand uncertainty changes into an insignificant negative effect for high uncertainty. That seems to suggest that the hypothesized moderating effect which was supposed to weaken the direct, positive relationship between IOICT and performance in fact even turns from a positive into a negative relationship. We submit that the low demand uncertainty better fits with the efficient supply chains of Fisher (1997). Apparently, in this context more advanced supply chain practices are not needed and simply exchanging information through electronic links is enough to enhance performance. However, the results suggest that there might possibly be even negative direct effects of implementing IOICT if the demand uncertainty is high. This direct negative effect is more or less a surprise. We do not yet fully understand this specific finding, but it yields additional evidence for the importance of considering contingencies such as demand uncertainty in research on the relationship between SCM practices and ICT.

Based on the findings with respect to the mediating effect of supply chain practices and the moderating role of demand uncertainty the conclusion seems justified that we do not yet fully

understand how ICT and different dimensions of supply chain integration interact and how they influence supplier performance. It seems that the mechanisms, through which supplier performance improvement can be realized, are different under different circumstances or contingencies. Our results even suggest that for certain situations IOICT and supply chain practices reinforce each other, whereas in other situations their effects are adverse. This is an interesting and important area for further research.

The starting point for this research was the oppositional views regarding the effectiveness of IOICT: ICT investments are necessary but these investments do not automatically result in better performance. Through this research, we contribute to solving this dilemma as the results show that companies should carefully assess the relevant circumstances. In highly uncertain environments IOICT investments should be made effective by simultaneously investing in supply chain practices, and particularly in information sharing. In case of low uncertainty, IOICT might help to improve performance without such additional efforts.

4.6 Conclusions

This paper identified a lack of knowledge regarding the effectiveness of ICT in supply chains. With respect to this lack of knowledge, the research provides two major contributions. First, based on the resource-based view we find support for the idea that IOICT enhances performance only via well-developed organizational capabilities. These capabilities are embedded in inter-firm cooperation and information sharing and can be associated with openness and joint-decision-making capabilities which help to increase velocity and responsiveness. More specifically, the results show the important role of information sharing in the effective use of IOICT. In other words, we show that the effects of IOICT are mediated by information sharing that underpins supply chain practices and cooperation. Second, based on contingency theory and the information processing theory, this study confirms that the relationship between IOICT, supply chain integration and supplier performance depends critically on the supply chain context. The main finding is that only if demand uncertainty is high, inter-organizational ICT actually improves supplier performance through supply chain integration initiatives. In other words, we show that the effect of IOICT via supply chain practices is moderated by demand uncertainty. This result also illustrates the value of both the information processing theory and contingency theory for SCM research. So far, not enough attention has been given to a contingency theory perspective in supply chain management literature and this paper advocates the importance of more research based on this perspective.

This research also provides several key insights for practitioners. The results show that firms should use their IOICT capabilities to enhance supplier performance to compete effectively in the marketplace. However, in doing so suppliers should take into account the following. First, decisions with respect to IOICT investments should include a clear understanding of the supply chain integration requirements. Of course the opposite is also true; decisions with respect to integrative practices should include a clear understanding of the required IOICT. Second, the result show that only firms that have to cope with high levels of demand uncertainty should invest heavily in both IOICT and corresponding integrative practices like information sharing by the buyer. However, if uncertainty in demand is low, IOICT investments might directly contribute to performance improvements. These combined findings help to solve the problem faced by managers as to how to make investments in ICT effective.

A limitation of this research is that the measurement of supplier performance is restricted to service performance. Generally, firms not only invest in inter-organizational ICT to improve the level of supply chain service, but also to reduce costs in the supply chain. Therefore, it would be interesting to investigate the effects of IOICT on supply chain costs. Another limitation is that we have not investigated different types of environmental uncertainty. Although our focus on demand uncertainty is a logical one, additional research focused on the role of technology uncertainty would be appropriate. It would also be valuable to examine other contingencies such as technology, market diversity or power.

The lack of a direct effect of cooperation on performance and the strong effect of cooperation on information sharing by the buyer, show that further research on how different dimensions of supply chain integration work together is desirable. Such future research should also take into account the effects of supply chain context.

CHAPTER 5

CONCLUSION

The goal of this dissertation is to examine how ICT has an impact on supply chain performance while considering the influence of supply chain characteristics. The empirical results of our study are discussed in the previous chapters. In this chapter we summarize the main findings and their theoretical and practical implications. Finally, we discuss the limitations of this dissertation, and argue how they provide opportunities for future research. While the conceptual model in Chapter one describes the relationship between ICT and SC performance, our empirical findings are related to the performance of the supplier in the supply chain relationship. Although, it is likely that our findings (specifically those in Chapter 2) can be extended to supply chain performance, this last chapter will focus on supplier performance for sake of simplicity.

5.1 Main findings

In the introductory chapter (Chapter 1), we developed a conceptual model that guided further research and helped to pose the relevant research questions. Following the conceptual model and the research questions identified, the results of this dissertation can be summarized into three main findings. First, we found that the relationship between ICT and supplier performance depends on the type of ICT and on the supply chain characteristics. Second, the results clearly indicate that inter-organizational ICT impacts supplier performance through supply chain integration while intra-organizational ICT acts as a condition for supply chain integration to improve supplier performance. Third, we found evidence for the moderating role of demand uncertainty on the relationship between inter-organizational ICT and supplier performance. We now discuss these main findings in greater detail.

5.1.1 The relationship between ICT resources and supplier performance

The first research question as proposed in Chapter 1 was: "Are ICT resources associated with improved supply chain performance?" Many existing studies have explored this research question but they report different, sometimes even opposing results (e.g. Kim and Narasimhan, 2002; Tai et al., 2010; Jeffers et al., 2008; Li et al., 2009). Driven by the contradicting findings, a systematic review and analysis of the relevant research was

conducted in Chapter 2. We found that the effect of ICT was generally positive. However, the main concepts ICT, supply chain management (SCM) and supply chain performance have been conceptualized and measured differently. It is thus hard to say which individual technologies positively affect specific performance measures. Further, the contextual factors have been largely ignored, therefore little is known about the effects of specific types of ICT under different circumstances. Our synthesis of the relevant literature in Chapter 2 shows that the majority of the present studies discussed the ICT-supply chain performance relationship without considering ICT classifications and the supply chain environment. We have argued that this is highly questionable, and that ICT is valuable for supply chain performance but the extent and dimensions are dependent upon some other factors, including the specific types of ICT, as well as the supply chain characteristics. Later, in Chapter 3 we have proven that inter- and intra-organizational ICT both have an impact on supplier performance. However, whereas inter-organization ICT has an impact on supplier performance through higher levels of supply chain integration, intra-organizational ICT acts as a condition for effective supply chain integration. This finding provides a possible explanation for the divergent results of the studies on ICT-supplier performance relationship. As a next step we examined in Chapter 4 the impact of supply chain characteristics on the relationship between inter-organizational ICT and supplier performance. We found that under low demand uncertainty in the supply chain, the direct relationship between inter-organizational ICT and supplier performance is stronger than under high demand uncertainty. To sum up, the findings presented in Chapter 3 and 4 strongly support the main idea presented in Chapter 2 that both the type of ICT and supply chain characteristics influence and shape the ICT-supplier performance relationship.

5.1.2 The improvement mechanism of ICT

With research questions 2 and 3, that are: “How do ICT resources generate improved supplier performance” and “What is the role of complementary organizational resources and business processes of electronically linked trading partners in generating and capturing ICT value?”, we aimed to understand better how ICT affects supplier performance and what the underlying mechanisms are that help to achieve these performance effects. Therefore, we examined not only the direct relationship between ICT and supplier performance but also the role of SCM in this relationship. With respect to SCM, we focus in this dissertation on the two integrative practices: information sharing and cooperation. Based on Chapter 2, it can be concluded that the role of SCM in ICT value generating and capturing has been examined in different ways in the literature. In Chapter 2 we concluded that studies generally fall within two categories. The first category regards SCM as the mediator that transfers the application of ICT into

improved supplier performance. Studies in the second category consider ICT resources and inter-organizational or SCM resources as complementary in their impact on supplier performance. The two categories offer unique insights into how inter-organizational resources influence the impact of ICT on supplier performance. However, the majority of studies does not consider both options – being the mediating and complementary model - for the role of SCM in the generation of ICT. In Chapter 3, we applied these two perspectives to explore the mechanism through which ICT has an impact on supplier performance and to explore the role of information sharing and cooperation in ICT value generation for supplier performance. This dissertation categorized ICT into inter- and intra-organizational ICT following a common distinction in the ICT application domain. For each type of ICT it was investigated how it interrelates with SCM, and consequently contributes to supplier performance. By implementing inter-organizational ICT, the supply chain partners can exchange information more precisely and quickly. Therefore, the cost of achieving information for the firms will decrease and the efficiency of information sharing between partners will improve. Moreover, inter-organizational ICT increases supply chain responsiveness through its effect on flexibility and speed.

In Chapter 3, we found that the application of inter-organizational ICT directly improves integrative practices such as information sharing, and these integrative practices lead to an improved supplier performance. With regards to intra-organizational ICT another mechanism has been detected. Intra-organizational ICT is implemented within firms but it does not change directly the external processes between organizations in a supply chain. However, according to the Resource Based View (RBV), firms must not only deploy and maintain ICT, but must incorporate ICT and non-ICT resources together to generate greater value (Brynjolfsson and Hitt, 2000). In the context of SCM, non-ICT resources include inter-organizational practices and structures that complement the different functions of ICT. However, what is not fully understood in the existing research is if and what intra-organizational ICT is necessary to assure that integrative practices are effective, This dissertation addressed this gap by investigating the complementarities between intra-organizational ICT and information sharing, and cooperation. In Chapter 3 we found that the use of intra-organizational ICT combined with information sharing and/or cooperation creates advantages that explain improved supplier performance.

In conclusion, in this dissertation we distinguish between the different mechanisms through which ICT improves supplier performance. We show that inter-organizational ICT has an impact on supplier performance through supply chain integration. With regard to intra-

organizational ICT, the results indicate that intra-organizational ICT does not have a direct impact on supply chain integration or supplier performance. However, the use of intra-organizational ICT provides a condition to make supply chain integration between partners more effective.

5.1.3 The role of demand uncertainty

The fourth research question of this dissertation is: "What is the role of supply chain characteristics in shaping ICT business value?" In Chapter 2, we assessed what is known regarding the impact of supply chain characteristics on the ability of firms to create and capture ICT business value. It was indicated that only a few existing studies examine the impact of supply chain characteristics on the relationship between ICT and supply chain performance. Supply chain characteristics shape the extent to which a firm can apply ICT successfully. The supply chain environment dictates the type of ICT required, the way in which it is usefully applied, the dimensions of value that may result, as well as the extent of value generated (Melville et al. 2004). However, few existing studies have explored the role of supply chain characteristics and the understanding of the association of particular supply chain characteristics with ICT business value is limited. In this dissertation, we focus on demand uncertainty, as one of the most important aspects of the supply chain environment, to investigate the effect of external factors on the relationship between ICT and integrative practices. Our findings make clear how demand uncertainty shapes the generation process and capture the value generated through inter-organizational ICT. By comparing environments with high demand uncertainty and low demand uncertainty, we are able to confirm that the higher demand uncertainty in a supply chain, the greater the extent to which firms are able to capture the benefits of inter-organizational ICT via integrative practices. Herewith, the results from Chapter 4 confirmed that supply chain characteristics play an important role in the process of ICT value generation in a supply chain.

5.1.4 Other findings

Besides the three main findings of this research as described above, the research also led to some other, unexpected findings. When comparing the models in Chapter 3 and Chapter 4, we discovered an unexpected and interesting finding. In Chapter 3, we processed the mediating role of information sharing and cooperation by regression. We found that information sharing mediates the relationship between inter-organizational ICT and supplier performance. However, contrary to our expectations cooperation is not found to mediate the relationship between inter-organizational ICT and supplier performance. In Chapter 4, we processed the

same model but with considering the relationship between information sharing and cooperation. The result of the structural equation model shows that there is a positive relationship between cooperation and information sharing. Cooperation between partners in the supply chain leads to information sharing and then results in improved supplier performance. This finding demonstrates that different integrative practices have different relationships with supplier performance. Cooperation is an integrative practice of firms at a more strategic level while information sharing is an integration practice of firms at the more operational level. Operational integration practices have a closer and more direct relationship with supplier performance compared to strategic integration practices. This idea is in line with Van der Vaart and Van Donk (2008) who indicate that there exist complex interactions between SCM factors. Therefore, it seems necessary to take into account these interactions when investigating more than one SCM factor. Our finding is in line with their argument and emphasizes the necessity for research incorporating different dimensions of supply chain integration.

5.2 Theoretical implications

The findings in this dissertation have four important implications for theory. First, we extended the framework of Melville et al. (2004) and derived an integrative theoretical framework to guide research on the impact of ICT on SCM and supply chain performance. Existing studies have employed several theoretical paradigms in examining the impact of ICT on supply chain performance including industrial organization theory (Belleflamme, 2001), sociology and socio-political paradigms (Chatfield and Yetton 2000), and the RBV (Jeffers et al., 2008). Each paradigm brings its own theoretical background and empirical tools to bear upon similar research questions. However, these approaches are divergent and the results have been mixed, which led to a fragmented research area with much simultaneous but separate discussion (Chan, 2000). Thus we sought to develop a conceptual framework that is rooted in theory inherently suitable for analyzing the complexity of ICT and supply chain performance. In addition, our proposed framework offers a logical formulation to enable the study of the rich contextual processes associated with managing ICT business value for supply chains. Based on the elaborated framework originally developed by Melville et al. (2004), this dissertation has illuminated the relevant issues through the lens of an integrated view. Synthesizing the within-firm, inter-organization and supply chain environment perspectives enabled us to analyze the process of ICT business value generation for SCM and the relevant factors that influence it. The integrative model includes three domains: supply chain, competitive environment and macro environment and describes how phenomena resident

within each domain shape the relationship between ICT and supply chain performance. Following the integrative framework, this dissertation shows ICT is valuable for supply chain performance, and specifically for supplier performance. It also shows that the extent and dimensions of ICT value for supply chain are dependent upon internal and external factors, including complementary organizational resources of the firm and its trading partners, as well as the supply chain environment. Our analysis provides a framework to guide future research and facilitates knowledge accumulation and creation concerning the impact of ICT on supply chains.

Second, we demonstrated that intra- and inter-organizational ICT influence supplier performance in different ways. Unlike the majority of past studies that focused on benefits of general ICT usage and its impact on supplier performance as a whole (Sanders and Premus, 2005, Hafeez et al., 2010), our study classifies ICT into inter- and intra-organizational ICT and evaluates how different kinds of ICT have an effect on supplier performance. Santhanam and Hartono (2003) indicate that the RBV provides a valuable way for the IS field to think about how information systems relate to firm performance. In particular, the RBV provides a cogent framework to evaluate the value of information systems and guidance on how to differentiate among various types of information systems. Classifying ICT into inter- and intra-organizational ICT is in accordance with the boundaries of firms. It helps us to recognize external and internal ICT resources (Wade and Hulland, 2004), and how they interact with other resources to influence supplier performance. As such, this dissertation provides a richer and much needed understanding of the impact of ICT on supply chains and a deeper understanding of the mechanisms of how intra- and inter-organizational ICT usage can result in a broad set of benefits for the supply chain. This finding highlights the variations that exist in different kinds of ICT, the differences in the value provided by each, and the importance of conveying these differential benefits. Moreover, our study adds to the growing body of work that expands and empirically tests the RBV in the context of ICT and SCM, further demonstrating its utility as a theoretical lens.

Third, drawing on the strategic management and organizational design literature, we advanced a configurational and systematical perspective on the impact of ICT. Our perspective is consistent with both process- and resource-based views and reflects a holistic systems approach. The process-oriented view has argued that the impact of ICT can be measured only through its intermediate, process-level contributions, because it is at this level where the first-order effects of ICT are often realized. Thus the relevant inter-organizational processes may mediate the payoff from ICT to supplier performance (Mukhopadhyay et al.,

1997; Bresnahan et al., 2002; Ray et al., 2004). In addition, the RBV emphasizes heterogeneous firm resource endowments as a basis for competitive advantage. In other words, firms should not only customize technological systems and deploy and maintain them, but they should also manage ICT and non-ICT resources together to generate greater value than they do alone (Brynjolfsson and Hitt, 2000). Considering the impact of ICT on supplier performance, many past studies only focus on the direct relationship between ICT and supplier performance (e.g. Jayaram et al., 2000; Iyer et al., 2009). Some other studies include SCM factors in their models in order to understand the mechanism through which ICT impacts supplier performance (e.g. Hill and Scudder, 2002; Heim and Peng, 2010). This study discusses two key supply chain integration factors: information sharing and cooperation. They play important roles in how ICT has an impact on supplier performance from both a moderating perspective and a mediating perspective. Our findings show that information sharing is the key factor to transfer the usage of inter-organizational ICT into improved supplier performance. On the other hand, intra-organizational ICT provides a condition to make information sharing and cooperation effective in improving supplier performance.

The results help to understand the different roles of information sharing and cooperation in the relationship between ICT and supplier performance. We have argued for a more systematic theory of ICT impact, one that goes beyond only a process or resource perspective, that offers a systematical model in which ICT resources are components of a bundle of resources that form a complex and interactive system. Our findings underscore the complexity of the causal structure and the factors that contribute to improved supplier performance. The result is a richer model that can serve as a guide for future research concerning the performance implications of ICT.

Finally, unlike the majority of past studies our study addresses the influence of the supply chain environment. The results show that the relationship between ICT resources and supplier performance is affected by supply chain environmental factors. This finding provides support for the relevance of contingency theory for supply chain management and operations management as recently advocated by Sousa and Voss (2008). Jarvenpaa and Leidner (1998) suggest that ICT resources may be particularly useful to firms operating in changing environments. ICT is critical to the firm to achieve performance in unstable environments if it helps to develop, add, integrate, and release other key resources over time (Wade and Hulland, 2004), in line with the contingency theory as used in Chapter 4. Finally our findings and the contingency perspective suggest that future studies on the impact of ICT need to be conducted regarding the influence of other supply chain characteristics.

5.4 Practical implications

This dissertation investigates the relationship between intra- and inter-organizational ICT, information sharing, cooperation and supplier performance. The findings of this study have several practical implications.

First, this study shows that inter-organizational ICT usage has a significant direct impact on supplier performance and a significant impact on both information sharing and cooperation. This finding underscores the important role that inter-organizational ICT plays in the functioning of supply chain organizations. The practical implication is that in order to improve supply chain integration implementing inter-organizational ICT is the first alternative to consider. This is an important point for managers as they consider investing in various ICT initiatives.

Second, although the finding that supplier performance can be improved by the integration of the supply chain partners is not new, our finding that supply chain integration plays different roles in the relationship between ICT and supplier performance provides interesting insights. The findings suggest that companies should not seek to justify investments in ICT in terms of their potential direct impact on supplier performance alone. ICT usage does not automatically lead to improved supplier performance. The usage of inter-organizational ICT will improve supply chain integration, and through higher supply chain integration better supplier performance will be reached. For intra-organizational ICT, the results show it rarely acts alone in creating improved supplier performance and it acts in conjunction with supply chain integration to impact on supplier performance. Supply chain integration and intra-organizational ICT function as complements in improving supplier performance. Business organizations typically make great financial and organizational investments in ICT, often assuming that acquisition of ICT is synonymous with correct ICT usage or that system integration is automatically in place (Sanders, 2007). Our findings imply that managers should not assume that all investments are equally effective. They should pay more attention to the processes and practices of supply chain integration between supply chain partners in place to capture the full potential of ICT implementation.

A final managerial contribution of this study is that it highlights the influence of the supply chain environment. The implication is that managers should not assume that all ICT investments are equally effective for each firm. The same level of ICT investment or usage does not guarantee the same result. In the complex environment of the supply chain, the

successful implementation of ICT projects is not so much a technological problem as well a management problem, requiring a thorough study of the supply chain conditions for the companies involved. ICT investment has to be aligned to the individual supply chain context. If supply chain members align their ICT investment and application to their supply chain conditions, and adopt a win–win collaboration pattern for their business interaction, ICT implementation will be better able to enhance supply chain integration and boost supplier performance.

5.5 Limitations and future research

As with all studies, there are limitations to this dissertation.

First, this dissertation relied on one sample, consisting of Chinese manufacturing firms. Clearly, having to rely on one sample in one country may limit the generalizability of our findings. Van Den Ende et al. (2001) indicate that the structure, institutions of economies and the increasingly interconnected global business environment affect firms' ICT choices and resulting performance outcomes. In the domain of our framework, we also infer that the macro environment would influence ICT application for supply chain performance. Future research could use the same questionnaire in other countries and compare the result to investigate whether macro factors influence ICT value generation in supply chain.

Second, this study used cross-sectional data which is static in nature. As a result, causality is not clear, and may not be unidirectional. For example, we argued that ICT usage enhances supply chain integration. Yet, other researchers have found that more supply chain integration calls for more ICT usage (Frohlich and Westbrook, 2002; Patterson et al., 2003). Future research with longitudinal designs may be particularly useful for examining such potential bidirectional effects. Meanwhile, the causal interrelations are analyzed and could imply temporal aspects, and collecting data over time from informants can offer richer insights. As indicated in Chapter 2, the utilization of ICT can be also viewed in different stages, from investment, through usage into capability. Thus, future research might be undertaken to test the impact of ICT on supply chain using time-series data.

Third, this dissertation focuses on the application of technologies and systems. However, a firm's capability to deploy ICT for improved performance also involves some other ICT resources. Bharadwaj (2000) indicates three key ICT resources and their relationship to a firm's capability to deploy ICT for improved performance: ICT infrastructure, human ICT

resources, and ICT enabled intangibles. Likewise, Dehning et al. (2002) identify three different formulations of ICT: ICT spending, ICT strategy (type of ICT), and ICT management. Thus, future studies could consider or include these ICT resources to discuss a firm's ICT capability in a more comprehensive way.

Fourth, our study focused on the main fundamental types of inter-organizational ICT such as E-mail, internet and extranet. Nowadays, other types of inter-organizational ICT such as wireless devices and mobile business solutions have the potential to make significant changes in supply chain management. Given the large expenditures ICT investments require, it seems important to consider the impact of different types of information technologies on supply chain performance.

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SUMMARY

The main objective of this dissertation is to explore the role of information and communication technology (ICT) in supply chains. We elaborated on the question whether, and if so, how ICT might impact supply chain (SC) performance. Based on a structured literature review and empirical data obtained through a survey conducted among Chinese manufacturing companies, this dissertation provides an initial understanding of the research on ICT business value for supply chains. In addition, it further enriches the knowledge of the underlying mechanisms of how ICT can improve supply chain management.

In Chapter 1 of the dissertation, a conceptual framework was developed to provide an integrative view of the studies on the impact of ICT on supply chains and SC performance. The framework suggests that ICT business value is generated by the deployment of ICT and complementary resources within supply chain processes. In addition, external factors also play a role in shaping the extent to which ICT business value can be generated. The relevant research questions are posed on the basis of the framework. Much of the prior research has only explored the direct relationship between ICT and SC performance. However, the explanations for underlying mechanisms are still lacking and important questions are not fully understood yet. The absence of complete answers to the research questions posed shows that we still know relatively little about the relationship between ICT and supply chain management. Following the conceptual framework and the research questions identified, the dissertation explored the impact of ICT on SC performance from a systematic and comprehensive perspective.

Chapter 2 of the dissertation first deals with a possible inconsistency in the reported findings within the survey-based research on the relationship between ICT, supply chain management (SCM) and SC performance. Based on a structured literature review of the major journals in the fields of operations management, logistics and information systems, we reviewed and classified survey-based research connecting ICT, SCM, and SC performance. The review evaluates current empirical results and aims at explaining the similarities and differences in reported findings in the current literature. A majority of the papers confirm a positive relationship between either ICT and SC performance or ICT and SCM. However, our analyses and findings did raise some doubts about the actual effect of ICT. Based on our in-depth analysis, we concluded that there are four main concerns. First of all, the main concepts ICT, SCM, and SC performance have been conceptualized and measured differently. Whereas the effect of ICT is generally positive, it is difficult to say which individual technologies

positively affect specific performance measures and how the mechanisms underlying the positive effects actually work. Secondly, ICT has often been conceptualized and measured as a holistic aggregate entity, ignoring the difference between technologies (e.g. ERP, EDI) and ignoring the difference between inter-organizational and intra-organizational ICT. Thirdly, contextual factors have been largely ignored, due to which little is known about the effects of specific types of ICT under different circumstances. Fourthly, the majority of the research conducted so far follows a similar path (ICT-SCM-SC performance), ignoring for instance possible interaction/moderating effects of ICT and SCM. Our overall conclusion is that current survey-based research does not pay sufficient attention to the complexities and interrelationships of the different aspects of supply chain integration and to the role of ICT in improving different aspects of SC performance. The initial confusion can be partly explained by the above concerns, but an additional explanation could be that disagreeing findings arose due to the different stages in which ICT was employed.

Chapter 3 contributes to our understanding of the role of ICT, as it distinguishes between intra-organizational and inter-organizational ICT. More specifically, our aim in this chapter is to understand the differences in the relationship between these two types of ICT and supply chain practices when it comes to improving performance. We provided evidence that both intra-organizational and inter-organizational ICT are crucial to performance improvement, but that their roles differ substantially. These differences are manifest in how each of the two ICT types relates to supply chain practices. More specifically, it turns out that supply chain practices mediate the positive effect of inter-organizational ICT on performance. In other words, inter-organizational ICT leads to more supply chain integration, which in its turn improves supplier performance. In contrast to this, intra-organizational ICT moderates the effect of supply chain practices on supplier performance. To put it differently, intra-organizational ICT provides a condition under which supply chain practices are more effective. These findings help us to understand the mixed results reported in the literature with respect to the relationships between ICT and supplier performance and the role of supply chain integration in that relationship. These findings confirm once more the value of the resource-based view (RBV) perspective in ICT and supply chain management research. According to the RBV perspective internal resources, such as intra-organizational ICT, can contribute to internal coordination and internal performance improvement. However, if complemented with other adequate organizational resources such as building relationships with key buyers through enhanced information sharing and cooperation, intra-organizational ICT can also improve the competitive position through its positive effect on external performance.

Chapter 4 explains the effect ICT has on supplier performance, especially inter-organizational information and communication technology (IOICT). As shown in Chapter 3, IOICT is vital to contemporary supply chains. However, investments in IOICT do not automatically lead to performance improvements. The existing literature is inconclusive with respect to the question how investments in IOICT can be made effective. First, in line with the resource-based view, we found support for the idea that IOICT enhances performance only when the organizational capabilities are well-developed. These capabilities are embedded in inter-firm cooperation and information sharing and can be associated with openness and joint-decision-making capabilities which help to increase speed and responsiveness. More specifically, the results show the important role of information sharing in the effective use of IOICT. In other words, we showed that the effects of IOICT are mediated by information sharing. Second, in line with the contingency theory and the information processing theory, this study confirmed that the relationship between IOICT, supply chain integration and supplier performance depends critically on the supply chain context. The main finding was that inter-organizational ICT improves supplier performance through supply chain integration initiatives, but only if demand uncertainty is high. In other words, we showed that the effect of IOICT via supply chain practices is moderated by demand uncertainty. This result also illustrates the value of both the information processing theory and the contingency theory for SCM research. So far, not enough attention has been paid to a contingency theory perspective in supply chain management literature; this study advocates the importance of more research based on this perspective.

The final Chapter 5 summarizes and integrates the main findings of this thesis and it provides final conclusions and suggestions for further research. Overall, this dissertation contributes to the understanding of how ICT impacts a supply chain. To this aim, we identified a number of insights allowing for effective managerial intervention to spur effective ICT application in supply chains. Above all, the insights highlight the way in which ICT impacts SC performance: this thesis shows that successful ICT usage will depend on the type of ICT, the relevant supply chain resources and the supply chain contingency characteristics.

SAMENVATTING

Het belangrijkste doel van dit proefschrift is het onderzoeken van de rol van informatie- en communicatietechnologie (ICT) in supply chains. In dit proefschrift onderzoeken we of en hoe ICT invloed kan hebben op de prestaties van een supply chain (SC). Op basis van een gestructureerde review van de literatuur en empirische gegevens die zijn verkregen met enquêtes die zijn uitgezet onder Chinese productiebedrijven, wordt in dit proefschrift inzicht gegeven in de wijze waarop ICT waarde creëert in supply chains. Daarnaast vergroot het onderzoek onze kennis over de mechanismen waarmee ICT supply chain management kan verbeteren.

In hoofdstuk 1 van dit proefschrift wordt een conceptueel kader ontwikkeld dat een integrale kijk biedt op studies over de invloed van ICT op supply chains en SC prestaties. Dit kader laat zien dat ICT bedrijfswaarde kan worden verkregen door de toepassing van ICT met aanvullende middelen binnen processen in de supply chain. Daarnaast spelen ook externe factoren een rol bij de mate waarin ICT waarde kan worden verkregen. Op basis van het conceptueel kader zijn de onderzoeksvragen opgesteld. In eerder onderzoek werd vaak alleen de rechtstreekse relatie tussen ICT en SC prestaties onderzocht, maar inzicht in de onderliggende mechanismen ontbreekt. Het ontbreken van volledige antwoorden op de gestelde onderzoeksvragen laat zien dat we nog steeds relatief weinig weten over de relatie tussen ICT en supply chain management. Op basis van het conceptueel kader en de gestelde onderzoeksvragen onderzoeken we in de rest van het proefschrift de invloed van ICT op de SC-prestaties vanuit een systematisch en alomvattend perspectief.

In hoofdstuk 2 van het proefschrift kijken we naar mogelijke inconsistenties in de bevindingen van het op enquêtes gebaseerd onderzoek naar de relatie tussen ICT, supply chain management (SCM) en SC-prestaties. We geven een gestructureerd literatuuroverzicht van de belangrijkste wetenschappelijke tijdschriften op de gebieden operations management, logistiek management en informatiesystemen, en classificeren het op enquêtes gebaseerd onderzoek waarin een verband wordt gelegd tussen ICT, SCM en SC-prestaties. In het overzicht worden de huidige empirische resultaten geëvalueerd met als doel verklaringen te geven voor de overeenkomsten en verschillen in de bevindingen in de huidige literatuur. Een meerderheid van de artikelen bevestigt een positieve relatie tussen ICT en SC of tussen ICT en SCM. Onze bevindingen en analyses doen ons echter twijfelen over het werkelijke effect van ICT. In een grondige analyse hebben we vier belangrijke bezwaren vastgesteld. Ten eerste zijn de belangrijkste concepten ICT, SCM en SC-prestaties vaak anders

geconceptualiseerd en gemeten. Het effect van ICT is over het algemeen positief, maar het is moeilijk te zeggen welke individuele technologieën een positief effect hebben op welke prestaties en hoe de mechanismen die aan de positieve effecten ten grondslag liggen werkelijk functioneren. Ten tweede is ICT vaak geconceptualiseerd en gemeten als een holistische, geaggregeerde eenheid, waarmee het verschil tussen technologieën (bijv. ERP, EDI) en het verschil tussen inter-organisatorische en intra-organisatorische ICT worden genegeerd. Ten derde worden contextuele factoren grotendeels genegeerd, waardoor er weinig bekend is over de effecten van specifieke soorten ICT onder verschillende omstandigheden. Ten vierde volgt een meerderheid van het onderzoek tot nu toe een soortgelijk pad (ICT-SCM-SC-prestaties) waarbij mogelijke interactie/moderating invloeden van ICT en SCM worden genegeerd. Onze conclusie luidt dat er in het huidige op enquêtes gebaseerde onderzoek niet voldoende aandacht wordt besteed aan de complexiteiten en onderlinge relaties tussen verschillende aspecten van supply chain integratie en aan de rol van ICT bij het verbeteren van verschillende elementen van de SC-prestaties. De bovenstaande bezwaren verklaren slechts deels de initiële verwarring; een mogelijke aanvullende verklaring is dat de tegenstrijdige bevindingen voortvloeien uit de verschillende fases waarin ICT wordt ingezet.

De bijdrage van hoofdstuk 3 is dat een onderscheid wordt gemaakt tussen intra-organisatorische en inter-organisatorische ICT, waardoor de rol van ICT beter kan worden begrepen. We richten ons met name op de verschillen in de relatie van deze twee soorten ICT met integratie activiteiten in de supply chain die gericht zijn op prestatieverbetering. Uit de resultaten blijkt dat zowel intra- als inter-organisatorische ICT van cruciaal belang zijn voor prestatieverbetering, maar dat hun rollen wezenlijk van elkaar verschillen. Deze verschillen komen naar voren in de relatie van elk van de twee soorten ICT met supply chain integratie. Meer specifiek blijkt dat supply chain integratie het positieve effect van inter-organisatorische ICT op de prestaties mediëren. Met andere woorden, inter-organisatorische ICT leidt tot meer integratie in de supply chain, wat op zijn beurt weer de SC-prestaties verbetert. Intra-organisatorische ICT modereert daarentegen het effect van supply chain integratie op de SC-prestaties. Anders gezegd, intra-organisatorische ICT biedt een voorwaarde waaronder integratie effectiever is. Deze bevindingen helpen ons de gemengde resultaten uit de literatuur te begrijpen met betrekking tot de relaties tussen ICT en SC-prestaties, evenals de rol van supply chain integratie in die relatie. Deze bevindingen bevestigen eens te meer de waarde van de resource-based view (RBV) in het onderzoek naar ICT en supply chain management. Volgens het RBV-perspectief dragen interne middelen, zoals intra-organisatorische ICT, bij aan de verbetering van interne coördinatie en interne prestaties. Als echter wordt aangevuld met de juiste andere organisatorische middelen, zoals het ontwikkelen van relaties met

belangrijke klanten door middel van betere samenwerking en het beter delen van informatie dan kan intra-organisatorische ICT, door zijn positieve effect op externe prestaties, ook worden geassocieerd met het verbeteren van de concurrentiepositie.