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Does ICT influence supply chain management and performance?

A review of survey-based research

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Abstract

Purpose – The purpose of this paper is to review and classify survey-based research connecting information and communication technology (ICT), supply chain management (SCM), and supply chain (SC) performance. The review evaluates present empirical results and aims at detecting explanations for similarities and differences in reported findings in the current literature.

Design/methodology/approach – The paper is based upon a structured literature review of the major journals in the fields of operations management, logistics, and information systems.

Findings – The point of departure in this paper is the possible inconsistency in reported findings within this field of research. The paper finds that measurements and constructs in all three major variables (ICT, SCM, SC performance) are different and often incomparable, and contextual factors are not systematically considered. Surprisingly, despite these differences, the papers reviewed show that generally, there is a positive direct or indirect effect of ICT on performance and SCM.

Research limitations/implications – The paper aims at reviewing the survey-based literature only. Findings from case studies and other types of studies are not considered. An implication of this paper might be to reconsider how future survey studies should be designed and what constructs and issues need to be incorporated. Specifically, the relationships between single technologies, aspects of SCM and performance dimensions need specific attention in future research.

Originality/value – The paper offers a systematic review that helps to further develop our understanding of the relationship of SCM, ICT, and SC performance.

Keywords Supply chain management, Information technology, Communication technologies, Information and communication technology, Survey-based research, Review

Paper type General review

1. Introduction and background

It is indisputable that information and communication technology (ICT) has an enormous effect on contemporary business. However, the relationship between ICT and the performance of supply chains (SC) is less straightforward. Some studies show that there is a positive relationship between them (Jayaram *et al.*, 2000; Olson and Boyer, 2003), but other studies present less evidence (Narasimhan and Kim, 2001; Da Silveira and Cagliano, 2006) or do not even find a relationship (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

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performance through supply chain management (SCM). Again the results are mixed. A number of studies (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 (Cagliano *et al.*, 2003; Ward and Zhou, 2006). However, others (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 (Sanders and Premus, 2005; Zhang and Dhaliwal, 2009) measure ICT in rather aggregate terms, while others focus on specific technologies like EDI (Lai *et al.*, 2008) or APS/ERP (Swafford *et al.*, 2008). Similarly, it seems that SCM and 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 SCM. First, 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 question which of the possible relationships have actually been taken into account in earlier research. Investigating these two questions, can help to find which aspects 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 SC (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. Section 2 will discuss the central concepts and present the research framework. In Section 3, we describe our methodology, explaining how we selected the papers for the review. Section 4 presents an analysis of the measurements of the three main concepts: ICT, SCM, and SC performance used in the reviewed papers. In Section 5, we explore different types of relationships found in the selected papers. Section 6 will analyse and discuss the findings. In Section 7, we will present the main conclusions and directions for future research.

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 (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 (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.

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.

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, 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 SC for the purposes of improving the long-term performance of the individual organizations and the SC as a whole. Again, this is a well-accepted definition that incorporates many different SCM aspects.

SC performance is usually defined in terms of reliability, responsiveness, flexibility, cost, and asset management efficiency (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 SC, 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, contextual factors can be defined as the main factors that determine and characterize the organizational setting. Relevant factors for SCM are for example the complexity of the SC, the position in the chain, and technological and demand uncertainty.

Figure 1 shows 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 collaboration (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 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.

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.

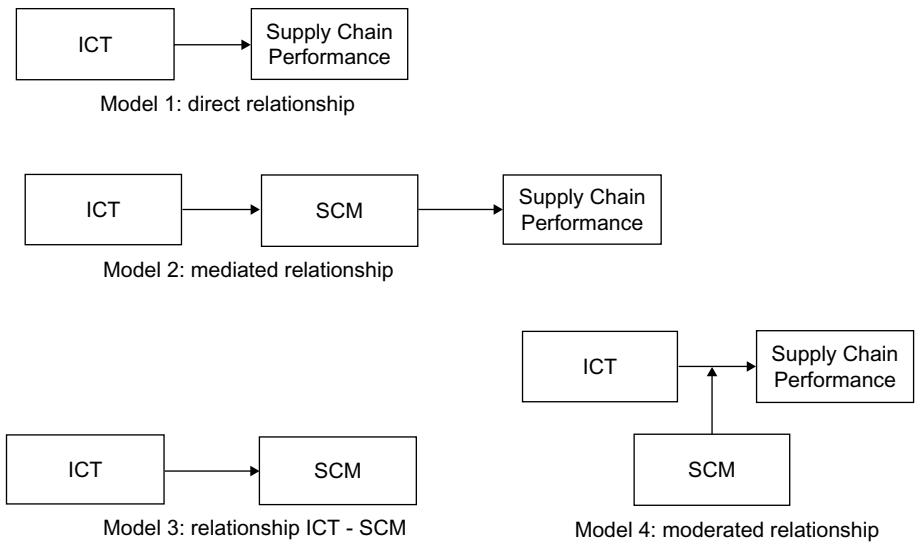

Figure 1.
Models about the relationships between ICT, SCM, and SC performance

3. Methodology: journal and paper selection

This paper aims to review survey-based research on SCM 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 (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 (Table I).

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 Ya, 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 (Table I).

Logistics journals have been chosen by analyzing journal assessments (see operations management references mentioned above) and by examining review papers in the field of SCM (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 (Table I).

Paper selection

(1) We focused our investigation on the period 1995 to mid-2010, 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. Owing 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

Journals (15)	Number of papers (40)
Management Science	0
Journal of Operation Management	11
Decision Sciences	3
International Journal of Operation & Production Management	3
Production and Operation Management	0
The International Journal of Production Research	5
The International Journal of Production Economics	5
MIS Quarterly	2
Information System Research	1
Journal of Management Information Systems	0
Information & Management	2
Journal of Business Logistics	4
International Journal of Physical Distribution and Logistics Management	3
International Journal of Logistics Management	0
Journal of Supply Chain Management	1

Table I.
Overview of journals and papers selected

interested in three factors: SC performance, SCM, ICT. 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 63 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; Chong *et al.*, 2009; Das and Nair, 2010); 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, 2005; Raghunathan and Yeh, 2001; Fan *et al.*, 2003; Graham *et al.*, 2004; Mclvor and Humphreys, 2004; Dehning *et al.*, 2007; Yao *et al.*, 2009) or the paper aimed at construct development only (Chen and Paulraj, 2004). Cagliano *et al.* (2005) is excluded because this paper seeks to review the results of a paper originally published in 2003 (Cagliano *et al.*, 2003).

As a result, we ended up with 40 papers for the final analysis (Table I).

As can be seen in Table I, *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 five 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. Finally, there is a remarkable increase in research over the last years: in 2009 till now already 11 papers fitting our criteria were published.

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.

4.1 ICT

Table II 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 RBV on organizations (Barney, 1986, 1991), which is often used to investigate the link between organizational performance and resources or technologies (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 (Bayraktar *et al.*, 2009; 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 SC strategies. Therefore, we choose not to incorporate them in Table II.

As Table II shows, most papers measure ICT usage, only nine papers measure ICT capability and three papers ICT investment. The distinction between these three stages and their possible impact on the management and performance of the SC 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 II also shows that a large number of different technologies have been used to measure ICT. Some papers (Subramani, 2004; Sanders and Premus, 2005) measure ICT as a general concept. On the contrary, other papers (Sanders, 2007; Tan *et al.*, 2010; 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 (Paulraj and Chen, 2007; 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.

Table II.
Measures and characteristics of ICT

Paper	Stage	Inter-organizational Technologies: Internet, web-based	Extranet	E-business	E-mail, fax	EDI	XML	Intra-organizational technologies: ADCS, TEDS	Electronic boards	APS	SFM	ERP, MRPII
Bayraktar *et al.* (2009)				X		X		X		X		X
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		
Dong *et al.* (2009)	U/C	X		X								
Frohlich and Westbrook (2002)	I/U	X										
Hafeez *et al.* (2010)	I		ICT measured in aggregated terms						ICT measured in aggregated terms			
Heim and Peng (2010)	U	X		Supported by software								X
Hill and Scudder (2002)	U					X						
Hsu *et al.* (2008)	U					X						
Iyer *et al.* (2009)	U	X		X		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		ICT measured in aggregated terms						ICT measured in aggregated terms			
Lai *et al.* (2008)	U					X						
Li *et al.* (2008)	U					X		X				X
Narasimhan and Kim (2001)	U		ICT measured in aggregated terms						ICT measured in aggregated terms			
Olson and Boyer (2003)	C	X										
Paulraj and Chen (2007)	U	X	X		X	X		X				
Paulraj *et al.* (2008)	U	X	X		X	X		X				
Power and Singh (2007)	U			X			X					

(continued)

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, MRPII
Rai *et al.* (2006)	C							X		X		X
Rosenzweig (2009)	U			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	ICT measured in aggregated terms						ICT measured in aggregated terms				
So and Sun (2010)	U		X			X						X
Subramani (2004)	U	ICT measured in aggregated terms						ICT measured in aggregated terms				
Swafford *et al.* (2008)	U	ICT measured in aggregated terms						ICT measured in aggregated terms except APS/ERP				
Tai *et al.* (2010)	U	X		X								
Tan *et al.* (2010)	C					X						
Wong *et al.* (2009)	U	ICT measured in aggregated terms						ICT measured in aggregated terms				
Vickery *et al.* (2003)	U					X					X	
Vickery *et al.* (2010)	U					X					X	
Ward and Zhou (2006)	I									X	X	X
Zhang and Dhaliwal (2009)	U/C	ICT measured in aggregated terms						ICT measured in aggregated terms				

Notes: 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

Table II.

4.2 Supply chain management

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

Table III lists the SCM factors mentioned in the sample. The philosophy of SCM is founded on collaboration among SC partners (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 (Sanders and Premus, 2005; Sanders, 2007) also consider internal collaboration.

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) SC 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) SC patterns, described as modes of interaction between the focal firm and its suppliers and/or customers.

(3) SC attitudes, described as attitudes of buyers and/or suppliers towards each other or towards SCM in general (Van der Vaart and Van Donk, 2008, p. 47).

As shown in Table III, 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 (2007) 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).

4.3 Supply chain performance

Table IV lists an overview of the performance measures used in the papers considered in this review. It is apparent from the second column of Table IV 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 (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 SC 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 IV, 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 (Swafford *et al.*, 2008, Subramani, 2004; Tan *et al.*, 2010) which might raise doubts about the face validity of the constructs.

Paper	SCM factor	Items: Practices	Items: Patterns	Items: Attitudes
Bayraktar *et al.* (2009)	Strategic collaboration and lean practices	X	X	
	Supplier selection practices	X		
	Procurement practices	X		
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		
Dong *et al.* (2009)	–			
Frohlich and Westbrook (2002)	Supply integration	X		
	Demand integration	X		
Hafeez *et al.* (2010)	Technological integration	X		
	Organisational integration	X		
	Supply chain relationship			X
Heim and Peng (2010)	Cooperation			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
Iyer *et al.* (2009)	–			
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.* (2008)	Supply chain integration	X		
Narasimhan and Kim (2001)	–			
Olson and Boyer (2003)	–			
Paulraj and Chen (2007)	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		
Rosenzweig (2009)	–			
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		
So and Sun (2010)	Perceived usefulness	X		

(*continued*)

Table III.
Factors and items used to measure SCM

Paper	SCM factor	Items: Practices	Patterns	Attitudes
Subramani (2004)	Business-process specificity	X		
	Domain-knowledge specificity	X		
Swafford *et al.* (2008)	–			
Tai *et al.* (2010)	Partner relationship	X		
	Buyer integrated process	X		
Tan *et al.* (2010)	Supply chain information alignment	X	X	
	Supply chain relational alignment	X	X	
Vickery *et al.* (2003)	Supply chain integration	X	X	X
Vickery *et al.* (2010)	Supply chain organisational initiatives	X		
Wong *et al.* (2009)	Supplier operational adaptation	X		
Ward and Zhou (2006)	Lean/JIT practices	X		
Zhang and Dhaliwal (2009)	–			

Table III.

4.4 Contextual factors

A number of authors has noticed that context of the SC (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), demand variability (Germain *et al.*, 2008), or environmental munificence (Rosenzweig, 2009). 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 half does not consider any variable as a context or control variable.

Table V lists two groups of contextual factors: firm characteristics and SC characteristics. Firm characteristics reflect the internal features of a company while SC characteristics describe influencing factors and/or characteristics of the SC or SC 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 Cagliano, 2006) all examine firm size, but in a different way: Subramani uses annual sales revenues; 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).

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; and

(3) contextual factors are considered to moderate the relationship between ICT and SC performance.

Paper	Construct	Cost	Delivery	Quality	Flexibility	Inventory	Process improvement	Innovation	Sales and financial
Bayraktar *et al.* (2009)	Operational performance	X	X			X	X		
Cagliano *et al.* (2003)	–								
Cagliano *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			
Dong *et al.* (2009)	Upstream operations improvement	X				X			
	Internal operations improvement						X		
	Downstream operations improvements		X						X
Frohlich and Westbrook (2002)	Operation performance	X	X			X			X
Hafeez *et al.* (2010)	Financial measures								X
	Efficiency measures						X		
	Coordination measures						X		
Heim and Peng (2010)	Labor productivity								X
	Capital productivity								X
Hill and Scudder (2002)	–								
Hsu *et al.* (2008)	Market performance		X	X	X				X
Iyer *et al.* (2009)	Operational performance		X		X	X			
	Financial performance								X
	Market performance								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						

(*continued*)

Table IV.
Performance constructs and items used

Table IV.

Paper	Construct	Cost	Delivery	Quality	Flexibility	Inventory	Process improvement	Innovation	Sales and financial
Kim and Narasimhan (2002) and Narasimhan and Kim (2001)	Differentiation		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.* (2008)	Supply chain performance	X	X	X		X			
Olson and Boyer (2003)	Organization performance	X	X				X		
Paulraj and Chen (2007)	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
Rosenzweig (2009)	Operational performance		X						
	Business performance								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	
So and Sun (2010)	Perceived benefits	X							

(continued)

Paper	Construct	Cost	Delivery	Quality	Flexibility	Inventory	Process improvement	Innovation	Sales and financial
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	
Tai *et al.* (2010)	Buyer immediate measure	X	X				X		
	Buyer organizational performance	X	X	X	X				
	Supplier performance	X	X	X					
Tan *et al.* (2010)	Firm performance			X					X
Vickery *et al.* (2003)	Customer service performance		X		X				
Vickery *et al.* (2010)	Agility		X		X			X	
Ward and Zhou (2006)	Lead time		X						
Wong *et al.* (2009)	Cost performance	X							
Zhang and Dhaliwal (2009)	Technology-enabled operation improvement	X	X	X		X			
	Customer service process performance		X	X					

Table IV.

Table V.
Contextual factors

Article	Contextual factors: SC characteristic	Contextual factors: Firm characteristic	Models of contextual factors: Context as control variable	Models of contextual factors: Context as variable	Models of contextual factors: Context as moderator
Bayraktar *et al.* (2009)	Integration specific inhibitors	Organization-specific inhibitors		P: Y ICT: Y SCM: Y	
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		
Dong *et al.* (2009)	Competitive intensity	Size; IT infrastructure	P: partly		ICT-P: Y
Frohlich and Westbrook (2002)					
Hafeez *et al.* (2010)					
Heim and Peng (2010)					
Hill and Scudder (2002)	Product characteristics and market type	Size		ICT: partly	
Hsu *et al.* (2008)		Region	SCM: N		SCM-P: Y
Iyer *et al.* (2009)	Demand unpredictability; product turbulence				ICT-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.* (2008)					
Narasimhan and Kim (2001)					

(*continued*)

Article	Contextual factors: SC characteristic	Contextual factors: Firm characteristic	Models of contextual factors: Context as control variable	Context as variable	Context as moderator
Olson and Boyer (2003)		Education; annual training; tenure in workforce		ICT: N	
Paulraj and Chen (2007)					
Paulraj *et al.* (2008)					
Power and Singh (2007)					
Rai *et al.* (2006)	Consumer demand predictability	Size	P: N		
Rosenzweig (2009)	Product complexity (1); market variability (2); environmental munificence (3)	Size	P: Y		(1)(2) ICT-P: N (3) ICT-P: Y
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)					
So and Sun (2010)					
Subramani (2004)	Replaceability; uncertainty	Size; years of association, retailer	P: N		
Swafford *et al.* (2008)					
Tai *et al.* (2010)					
Tan *et al.* (2010)					
Vickery *et al.* (2003)					
Wong *et al.* (2009)	Environmental uncertainty				ICT-SCM:Y; SCM-P:Y
Ward and Zhou (2006)					
Zhang and Dhaliwal (2009)					

Notes: P – the supply chain performance; Y – existing influence; N – no influence; ICT-P – the relationship between ICT and performance; ICT-SCM – the relationship between ICT and SCM

Table V.

The first group is specifically aiming at improving the reliability of the models. It is assumed that these control variables (such as size or industry) 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. Cagliano *et al.* (2006) find a significant effect of control variables on SCM, while Rosenzweig (2009) finds a negative effect of size on performance.

The second group contains five papers that assume a relationship between contextual factors and ICT. Table V (fifth column) shows that the results are rather mixed. The last group contains six papers, that all confirm the influence of contextual factors on the relationship of SCM or ICT with performance. It seems that in recent papers more attention has been paid to context.

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 shown in Figure 1.

5. Core findings: the effects of ICT

Following the models shown in Figure 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 VI shows the distribution of the papers over these different relationships.

ICT-SC performance

The majority of the papers show that ICT at least has some effect on SC performance. Five papers do not support the positive effect: Jeffers *et al.* (2008), Li *et al.* (2008), Tan *et al.* (2010), Vickery *et al.* (2010), 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-SC 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 (Sanders and Premus, 2005; Sanders, 2007; Iyer *et al.*, 2009) combine some of the basic models of Figure 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 three papers (Kim and Narasimhan, 2002; Jeffers *et al.*, 2008; Vickery *et al.*, 2010) explicitly investigate the moderating effect of SCM on the ICT-performance relationship.

ICT-SCM

The final group in Table II lists the papers that investigate a relationship between ICT and SCM. Within this group some papers exclusively search for the relationship

Table VI. Distribution of papers over types of relationships

Relationship	ICT – supply chain performance (Partly) confirmed	ICT – supply chain performance Not confirmed	ICT – (SCM) – supply chain performance Mediated	ICT – (SCM) – supply chain performance Moderated	ICT – SCM (Partly) confirmed	ICT – SCM Not confirmed
Paper	Bayraktar *et al.* (2009), Da Silveira and Cagliano (2006), Dong *et al.* (2009), Hafeez *et al.* (2010), Heim and Peng (2010), Iyer *et al.* (2009), Jayaram *et al.* (2000), Kim and Narasimhan (2002), Lai *et al.* (2008), Narasimhan and Kim (2001), Olson and Boyer (2003), Rosenzweig (2009), Saeed *et al.* (2005), Sanders (2007), Sanders and Premus (2002), Sanders and Premus (2005), Swafford *et al.* (2008), Tai *et al.* (2010), and Zhang and Dhaliwal (2009)	Jeffers *et al.* (2008)[a], Li *et al.* (2008), Tan *et al.* (2010), Vickery *et al.* (2010), and Ward and Zhou (2006)	Devaraj *et al.* (2007), Frohlich and Westbrook (2002), Hsu *et al.* (2008), Iyer *et al.* (2009), Kent and Mentzer (2003), Li *et al.* (2008), Paulraj *et al.* (2008), Paulraj and Chen (2007), Rai *et al.* (2006), Rosenzweig (2009), So and Sun (2010), Tan *et al.* (2010), Sanders (2007), Sanders (2008), Sanders and Premus (2005), Subramani (2004), Tai *et al.* (2010), Vickery *et al.* (2003), Ward and Zhou (2006), and Wong *et al.* (2009)	Jeffers *et al.* (2008), Kim and Narasimhan (2002), and Vickery *et al.* (2010)	Cagliano *et al.* (2003), Devaraj *et al.* (2007), Hafeez *et al.* (2010), Heim and Peng (2010), Hill and Scudder (2002), Hsu *et al.* (2008), Kent and Mentzer (2003), Li *et al.* (2008), Paulraj and Chen (2007), Paulraj *et al.* (2008), Power and Singh (2007), Sanders (2008), Sanders and Premus (2005), So and Sun (2010), Subramani (2004), Tai *et al.* (2010), Tan *et al.* (2010), and Vickery *et al.* (2003)	Cagliano *et al.* (2006), Devaraj *et al.* (2007), and Zhang and Dhaliwal (2009)

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

between ICT and SCM (Cagliano *et al.*, 2003, 2006) while others investigate this relationship in the context of the ICT-SC relationship via SCM (Paulraj and Chen, 2007). 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 Dhaliwal (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. First, 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), Jeffers *et al.* (2008), and Vickery *et al.* (2010) in our search. Second, to some extent the empirical findings are less confusing and contradicting than we originally expected. However, as indicated in Section 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.

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 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.

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. First of all, it should be realised that survey research has certain limitations. 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 (Meredith, 1998; Karlsson, 2009). While keeping this in mind, two main problems can be detected with respect to concepts and measurements.

First, 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 SC 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, 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.

Second, 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 15 different constructs related to SCM in their review of SC research. Van der Vaart and Van Donk (2008) found already more than 30 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. Others use a highly aggregated measure. Heim and Peng (2010) state that such an approach does not allow the isolation of the impact of specific IT applications. However, assessing the impact, might be important for improving specific plant operations. Specifically in the context of ICT and SCM this seems true 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, but also by Subramani (2004) who found 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 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. Finally, 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 (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 SCM 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 SCs, having distinctive characteristics as well. It might be clear that 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 SC 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. In line with these findings, Chong *et al.* (2009) – not included in our sample, as explained in the methodology – show that product complexity, trust, transaction frequency and product volume positively influence the adoption of e-collaboration.

Power and dependency have been taken into account in previous SCM research (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 (Hill and Scudder, 2002; Olson and Boyer, 2003; Cagliano *et al.*, 2003; Dong *et al.*, 2009) directly show the influence of contextual factors such as competition, size and position in the chain on ICT, SCM, performance, and on their relationship. The effect of the firm's position in the SC is likely to be equivalent with the firm's power and dependency, which was discussed above.

6.2 Analysis of relationship findings

Within our sample of published research, only eight 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.

First, two recent papers (Tan *et al.*, 2010; Vickery *et al.*, 2010) do not find a direct effect of EDI. However, Tan *et al.* (2010) find a mediating effect, while Vickery *et al.* (2010) show a moderating effect of EDI. Further, it seems that implementing ERP/MRPII is not always having a direct, positive effect 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 II that shows that four of the eight non-confirming papers (Cagliano *et al.*, 2006; Jeffers *et al.* (2008); Li *et al.*, 2008; 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 eight 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 or EDI can be attributed to different effects in different contexts. Welker *et al.* (2008) find in their study that a positive effect of ERP systems is more likely in a more stable business environment.

Second, 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.

Third, 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 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 cannot 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 paper that measures ICT investment (Ward and Zhou, 2006), does not find a relationship with performance, while the papers using ICT capability measures direct 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.

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 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 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-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 SCM (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 SC 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 RBV 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 paper 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 Nunnally (1978) for a more general discussion). 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. Das and Nair (2010) offer an interesting list of information technologies in different manufacturing stages:

design, production, and planning. That variety 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 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. Vickery *et al.* (2010) show that there is no separate effect of ICT and SCM, while there is a joint effect. 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- 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, in line with a recommendation for further research of Rosenzweig (2009).

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 RBV of the firm. Understanding such organisational aspects will be beneficial for getting organisations out of there ICT crises.

Finally, a meta-analysis (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.

As might be concluded from the above recommendations, there is not yet a study that comprises all characteristics that we would like it to have. Ideally, future research should include a comprehensive list of ICT (as in Das and Nair, 2010) or a well-motivated subset of that list, a set of SCM practices (Chen and Paulraj, 2004) and would investigate the effect of the interaction between those subsets (as in Vickery *et al.*, 2010) on various performance measures. Alternatively, based on theoretical considerations, researchers can make a choice and investigate single ICT-technologies' effect on performance, if supported by SC practices. Following Rosenzweig (2009), it is clear that contingencies need to be incorporated. Some recent papers have made a step towards realizing some of the above-mentioned directions of future research. Tan *et al.* (2010) and Vickery *et al.* (2010) show that there is no direct effect of EDI, but there is a mediated or moderated

effect through a SC practice, which shows the importance of adapting organisational practices. Rosenzweig (2009) shows the effect of contextual factors. As such these papers are exemplars for current and future research. As indicated above, much more is needed.

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 RBV. So for managers, our review clearly indicates that just investing in technology is not the answer. It is also required to embed technology into the working practices of the organisation (to achieve organisational capabilities) and adapting SCM and ICT to the organisational context (e.g. level of competition, uncertainty in demand). Our review and the studies that take context and SCM practices into account will help managers in choosing those IT-investments, and developing those capabilities that will result in a competitive advantage of using ICT.

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