Information and communications technologies as an enabler of supply chain integration

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Abstract:

This study is a meta-research analysis that examined the role of information and communication technologies (ICTs) as an enabler of supply chain integration. Our analysis covered 55 papers in 34 journals published between 2007 and 2017. RFID systems were the most investigated ICTs in the supply chain integration literature. Besides its impact as an independent variable, ICTâ€™s mediating and moderating roles are also noteworthy. Our study has demonstrated the underutilization of theories in general, dominance of surveys and single case studies, and future research opportunities for the underutilized IS types in SCI. Based on the findings, we proposed a research framework. Our framework illustrated two types of moderating factors between the use of ICT and level of SCI: (1) ICT-related factors as an enabler of SCI, and (2) other factors as an enabler of SCI. ICT-related factors are suitability, criticality, and maturity of ICT; ICT capabilities of, and integration within, an organization; ICT integration with SC partners; and technological differences among available ICT applications. Other factors are availability of industry standards; open information-sharing environment; institutional pressures and organizational culture; and involvement of top management.

Keywords: Information Technology (IT) | Information and Communications Technology (ICT) | Supply Chain Integration (SCI)

Article:

***Note: Full text of article below**

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Completed Research

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Abstract

This study is a meta-research analysis that examined the role of information and communication technologies (ICTs) as an enabler of supply chain integration. Our analysis covered 55 papers in 34 journals published between 2007 and 2017. RFID systems were the most investigated ICTs in the supply chain integration literature. Besides its impact as an independent variable, ICT's mediating and moderating roles are also noteworthy. Our study has demonstrated the underutilization of theories in general, dominance of surveys and single case studies, and future research opportunities for the underutilized IS types in SCI. Based on the findings, we proposed a research framework. Our framework illustrated two types of moderating factors between the use of ICT and level of SCI: (1) ICT-related factors as an enabler of SCI, and (2) other factors as an enabler of SCI. ICT-related factors are suitability, criticality, and maturity of ICT; ICT capabilities of, and integration within, an organization; ICT integration with SC partners; and technological differences among available ICT applications. Other factors are availability of industry standards; open information-sharing environment; institutional pressures and organizational culture; and involvement of top management.

Keywords

Information Technology (IT), Information and Communications Technology (ICT), Supply Chain Integration (SCI).

Introduction

This research aims to understand the role of information and communication technologies (ICTs), and in particular the role of interorganizational systems deployed across the supply chain, such as RFID (Radio Frequency Identification), ERP (Enterprise Resource Planning), EDI (Electronic Data Interchange), and e-business (electronic business) systems as enablers and enhancers of supply chain integration**.**

Supply chain integration is one of the main pillars of supply chain management (SCM). A supply chain is defined as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer" (Mentzer, 2001, p. 4). SCM is the management of upstream and downstream relationships (Christopher, 1998), and the coordination of activities (Larson et al., 1998). Although supply chain integration (SCI) does not have a universally accepted definition (Fawcett and Magnan, 2002), it is broadly associated with the level to which a firm strategically links and aligns processes with suppliers and customers (Mentzer, et al. 2001; Leuschner, et al. 2013). SCI was defined by Leuschner et al. (2013) as "the scope and strength of linkages in supply chain processes across firms" (p. 34). The terms integration, collaboration, and coordination are also interchangeably applied in the supply chain literature.

In spite of the importance of supply chain integration, it has proven to be difficult to implement (Sabath and Fontanella, 2002) because information-sharing makes planning and resource management more difficult, and due to lack of knowledge and structural framework as to how to achieve internal and external integration (Wolf, 2011). The lack of integration may result in poor performance of the supply chain (SC) (Kanda and Deshmukh, 2008). Ramdas and Spekman (2000) report consequences of lack of integration as: inaccurate forecasts, low capacity utilization, excessive inventory, inadequate customer service, inventory turnover, inventory costs, time to market, order fulfillment response, quality, customer focus and customer satisfaction. Fisher et al. (1994) has cited a study of the US food industry, which estimated that poor integration among SC partners was wasting $30 billion annually.

Supply chains can span over hundreds of stages and dozens of geographical locations globally. Today, a globalized market is electronically connected and dynamic in nature (Gunasekaran & Ngai, 2004). The globalization and technology are complementary to each other, and the emerging of new business models such as e-Business and e-Commerce is a result from both (Rosen & Howard, 2000). The development of ICTs is believed to be not only a necessity that improves the information sharing and communication in the globalized supply chain, but also to enhance the business efficiency and competitiveness.

Scholarly literature has examined the role that IT plays in promoting collaboration and information sharing both inside and across organizational boundaries (e.g., Barua et al., 1995; Lind & Zmud, 1995; Pickering & King, 1995; Quinn et al., 1996). Huber (1990) argued that IT is a variable that can be used to enhance the quality and timeliness of organizational intelligence and decision making, thus promoting organizational performance. Dewett and Jones (2001) proposed a framework in which IT is a moderating construct and positively influences the relationship between organizational characteristics and organizational outcomes. Information technologies enhance the business integration and improve efficiency; in turn, these positive business outcomes increase information efficiencies and synergies. Gunasekaran and Ngai's (2004) literature review on the role of information systems in supply chain integration and management demonstrated that IT is an essential factor for survival of the businesses and improvements in competitiveness of firms. They also categorized IT-enabled SCM in six major areas – strategic planning, virtual enterprise, e-commerce, infrastructure, knowledge and IT management, and implementation. Sarac et al.'s (2010) literature review on the impact of RFID technologies on supply chain management concluded that main advantages of RFID technologies in supply chains are the improvement of traceability and visibility of products and processes, the increase of efficiency and speed of processes, the improvement on information accuracy, reduction of inventory losses, and the facilitation of management through real-time information.

Due to the inconsistencies demonstrated in the previous literature and lack of a meta-analysis in the last ten years, we set out to conduct a meta-analysis to find out the overall landscape regarding information and communication technologies, and their role in supply chain integration. Through this study, we want to address this question: "*What is the role of information and communications technology as an enabler and enhancer of supply chain integration?*"

Some studies indicate a positive and significant correlation between SCI and performance (e.g., Leuschner, et al. 2013). In order to develop a complete picture of the relationship between ICT and SCI, we conducted meta research spanning 11 years. Furthermore, we categorize the dimensions of integration and evaluate the impact of ICT on these various dimensions.

Our research contributes to the literature by taking a meta-analysis approach in efforts to provide an overview of the extant literature between 2007 and 2017. Our research also contributes to categorizing the research dimensions, to synthesize the findings, and offer directions for the future researchers. Further, the research also intends to offer supply chain managers insightful views regarding the application of information and communication technologies, and their effectiveness in helping businesses in the pursuit of higher performance and competitive advantage.

The rest of the paper is organized as follows. In section 2, we briefly review the literature to develop our methodological framework. Section 3 provides the results and insights from the SCM and IS literature analysis. This section includes relationships among variables, trends in topics, methodologies, and research approaches. Section 4 discusses the results. Finally, section 5 provides implications for research and theory, contributions, limitations, and future research avenues. Section 6 concludes the article.

Research Methodology

Preparation of Pool of Papers

The scope of this research focuses on available supply chain-related academic journals that studied the relationship between information communication technologies and supply chain integration. Keywords that were used in our search at Google Scholar and databases such as Academic Search Complete, ArticleFirst, Business Source Complete, and WorldCat.org are combinations of "Information Systems", "Information Technology", "Information and Communication Technologies", and "Interorganizational Systems" with "Supply Chain Management" and "Supply Chain Integration" (e.g. "Information Systems" and "Supply Chain Integration"). These search keywords were checked within titles, abstracts, and keywords of articles. We also used the words "collaboration", "coordination", and "cooperation" instead of integration, in our search.

The following flow chart describes the literature search procedure taken by this study.

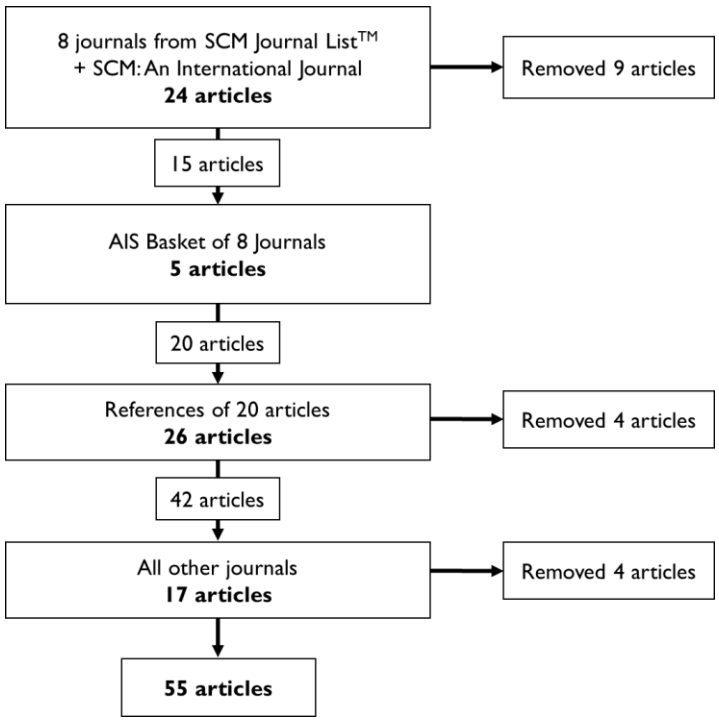

Figure 1. Literature Review Search Process

Coding Procedure & Intercoder reliability

We adopted the three-phase literature analysis approach proposed by Cumbie et al. (2005). In the first phase, we conducted our preliminary search focusing on the top eight journals from the SCM Journal List from year 2007 to 2017. The SCM Journal List ranking is an annual ranking of universities' supply chain management research output in the leading supply chain management journals. The ranking is based on publications during the prior five years. These journals are Journal of Supply Chain Management, Journal of Operations Management, Operations Research, Journal of Business Logistics, Manufacturing & Service Operations Management, Production and Operations Management, Decision Sciences, and Management Science. "Supply Chain Management: An International Journal" was also added to these journals.

Twenty-four papers were selected based on the search. In the first round of preliminary coding, two authors of this paper coded 10 articles separately in order to discuss their findings and minimize the differences in their coding. The results were compared and the variations in coding were discussed to

make sure the same understanding of definitions of keywords and research terms. Four out of 10 papers were deemed irrelevant for our study by coders and were removed. For instance, although some papers included relevant terms in their abstracts, their main theme and findings addressed irrelevant issues to our research topic. The remaining 19 articles were coded by the two authors separately again. Results were compared and discussed, and five of them were removed. The two coders had 81% intercoder reliability for the 10 articles, and 87% intercoder reliability for the 19 articles, respectively.

In the second phase, the literature search was extended to the 'Senior Basket of Eight' AIS journals based on the same framework for the same time frame. The AIS Basket of Eight are: European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems, MIS Quarterly. Five articles fit the keywords search.

Due to the insufficient number of search results, the two authors decided to extend the scope of search by checking all reference articles listed in each of selected 20 articles. This search generated 24 additional articles. Besides, search on Google Scholar was extended to any journals published between 2007 and 2017. Seventeen additional articles met the criteria.

In the third phase, two authors conducted a thorough review of the 63 selected articles. During this review, eight more articles were removed; four out the 24 articles from the reference lists and four from other journals. The final number of articles was 55. In this round, detailed information regarding each article were recorded, including author, year of publication, name of journal, research questions, type of information technology studied, dimension of supply chain integration, theory used, research approach adopted, research method applied, sample size, studied countries, independent variables, dependent variables, moderating variables, mediating variables, control variables, key findings, and suggested future research. The review in the third phase provides descriptive information for further analysis. The third phase is discussed in two steps below: general analysis and detailed discussion (Tranfield et al., 2003).

Analysis and Results

In total, 55 papers from 34 journals were examined. Out of these 55 papers, 28 articles were published at top journals in the fields of SCM and IS. These journals are listed in Table 1 with asterisk. Surprisingly, Operations Research, Manufacturing & Service Operations Management, European Journal of Information Systems, Information Systems Journal, Journal of AIS, and MIS Quarterly have not generated any relevant articles for the period covered according to the methodology we followed and the search keywords we used. However, Pacific Asia Journal of the AIS had two articles in that period. All 11 top journals, and journals with more than one article are shown in Table 1.

Journals	Number of Articles
Journal of Operations Management*	6
Supply Chain Management: An International Journal*	5
Int. Journal of Production Economics	3
Journal of Management Information Systems*	3
Journal of Supply Chain Management*	3
Benchmarking: An International Journal	2
Decision Sciences*	2
Industrial Management & Data Systems	2
Information Systems Research*	2
Pacific Asia JAIS	2
Production and Operations Management*	2
Journal of Business Logistics*	1

Journal of Information Technology*	1
Journal of Strategic Information Systems*	1
Management Science*	1
Other 19 Journals	19
TOTAL	55

Table 1. Articles by Journal

The number of articles by each year is, respectively starting in 2007 until 2017, 16, 3, 4, 6, 5, 6, 3, 5, 1, 4, and 2. The year 2007 had the highest production; the average for the remaining years is about four papers.

Out of 55 papers, 12 did not identify any countries in which the research was carried out. Although US-centric research ranked at the top with 9 studies, 13 studies were conducted for two or more countries.

Countries	Count		Countries	Count
Not identified	12		Regional	3
USA	9		Canada	1
Global	5		Finland	1
More than 2	5		India	1
China	4		Singapore	1
2 countries	3		Slovenia	1
Australia	2		Taiwan	1
Greece	2		Thailand	1
Hong Kong	2		UK	1
			TOTAL	55

Table 2. Countries included in the papers

42% of the articles did not use any theoretical framework in their research. Some of the articles utilized more than one theory. Resource based theories dominated the research with respect to the relationship between SCI and IS. Besides the resource-based view (8), transaction cost economics (6), institutional theory (3), and contingency theory (2) were the theories used in more than one study.

Eleven articles used more than one research method. Therefore, the number of research methods (69) is more than total number of articles (55). The survey method was the most common used in more than half of the studies (30). The case study method (9 articles with case study conducted at one organization, and 3 with case studies conducted more than one organization), use of secondary data (7), interview (6), and simulation (5) also registered appreciable numbers.

Three overall approaches were used in the conduct of research: descriptive (2), interpretive (18), and positivist (35). As is in other IS research, the positivist approach was the most dominant.

We also examined the particular ICT(s) being investigated in the literature (Table 4). Note that 53% of the papers were built upon more than one ICT type. Interorganizational systems were defined as "information and communication technology-based systems that transcend legal enterprise boundaries" (Paulraj & Chen, 2007). The terms IT and ICT have been used in many papers in order to indicate interorganizational systems without specifying a system or IT – so these terms were included. Together, IT, ICT and interorganizational systems accounted for 16 IS types in our analysis. A wide variety of technologies were used in the 55 papers amounting to of 112 references. The highest ones are: RFID-integrated systems (12), web services (12), EDI (11), IT (10), e-business (7), ERP (6), Decision Support Systems (5), and interorganizational systems (4).

ICT types	Count		ICT types	Count
RFID	12		Open standards	3
Web services	12		SCM systems	3
EDI	11		B2B	2
IT	10		E-procurement	2
E-business	7		Extranet	2
ERP	6		ICT	2
Decision Support Systems	5		Point-of-sale	2
Interorganizational systems	4		Others	26
Bar coding	3		TOTAL	112

Table 3. ICT Types

Based on the review, we developed a preliminary taxonomy for the types of integration (Table 5). SCI was examined from different perspectives in 55 papers. For instance, Liu et al. (2016) constructed SCI with four items – information sharing, synchronized planning, operational coordination, and strategic partnership. Thun (2010) investigated the implementation of Internet-based IT in global supply chains in terms of supplier and customer integration. The most investigated SCI categories were IS integration (24), followed by customer integration (12), partnership (11), logistics integration (10), supply chain integration (10), and supplier integration (9). IS integration was composed of various ICT-related integration concepts such as information sharing, IT integration, IOS integration, information integration, technical integration, transaction information management integration, and infrastructure integration.

SCI categories	Count		SCI categories	Count
IS integration	24		Buyer-seller integration	2
Customer integration	12		External integration	2
Partnership	11		Global SC integration	2
Logistics integration	10		Organizational integration	2
SC integration	10		Strategic integration	2
Supplier integration	9		Collaborative planning	1
Business process integration	5		Collaborative product development	1
Cross-functional integration	3		Internal integration	1
Operational integration	3		TOTAL	100

Table 4. Supply Chain Integration (SCI) categories

We also looked at independent and dependent variables in past research. IS integration (14), IS capabilities (10), relationship building (10), and IOS characteristics (5) were the most investigated independent variables whereas performance (24), relationship building (5), SC flexibility (5), supplier integration (5) were the most common dependent variables. Mediating variables included IS integration, logistics integration, relationship building, and SCI. IS integration was also included as a moderating variable while environment, product characteristics, and IT use were other commonly used moderating variables. Firm characteristics, industry characteristics, IS capabilities, and relationship building were included as control variables.

Discussion and Proposed Research Framework

The effect of ICTs on supply chain integration depends on contingencies which are suitability, criticality and maturity of the technological approach; type of ICT, its characteristics, and assimilation; ICT capabilities of an organization; ICT integration within an organization; ICT integration with SC partners; technological differences among available IT applications; and IT architecture flexibility. Furthermore, geographical dispersion of retailers and supplier plants; availability of industry standards; higher product complexity, availability of an open information-sharing environment; institutional pressures and organizational culture; and involvement of top management have been also identified as contingencies which moderates the impact of ICT on SCI (Pramatari, 2007; Buijs & Wortmann, 2014; Tafti et al., 2013; Cannella et al., 2014; Sahaym et al., 2007; Grover & Saeed, 2007; Liu et al., 2010; Jitpaiboon & Sharma, 2013; Liu et al., 2016).

Therefore, ICT's mediating and moderating roles have been prevalent in the literature compared to ICT's direct impact as an independent variable (Jitpaiboon & Sharma, 2013; Klein et al., 2007; Cheung et al., 2012; Prajogo & Olhager, 2012; Rajaguru & Matanda, 2013; Adams, 2014; Gonzalvez-Gallego et al., 2015; Mandal, 2016; Vanpoucke et al., 2017; Hadaya & Cassivi, 2007). Rather than the availability of IS as a resource, its connecting role as a mediator and moderator are valued as a rare capability on the firm and/or supply chain performance (Bharadwaj et al., 2007; Fawcett et al., 2011; Devaraj et al., 2007; Li et al., 2009).

Based on these findings, we propose a research framework as below:

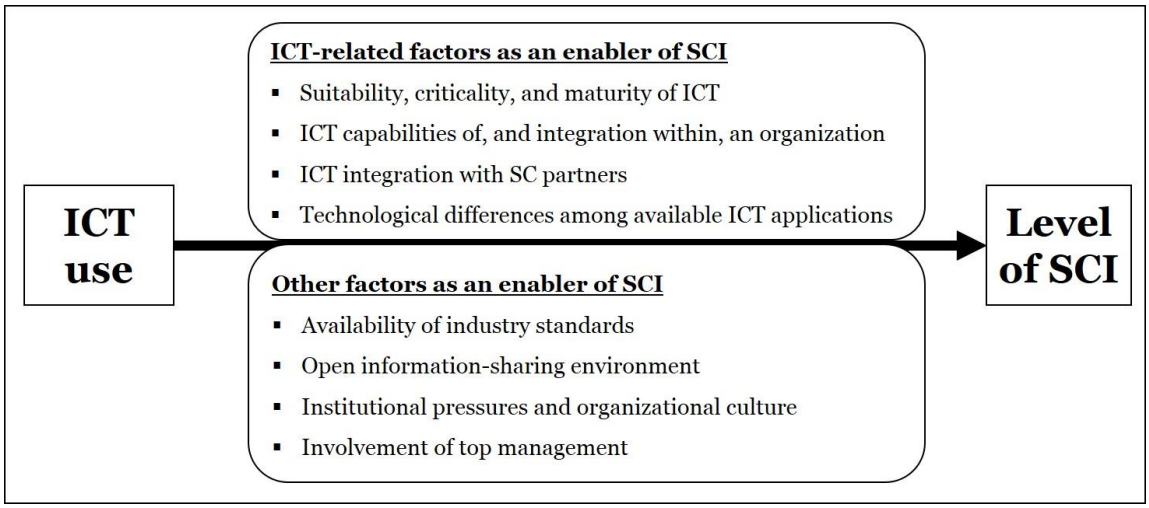

Figure 2. Proposed Research Framework for the role of ICT and other factors in SCI

Our framework illustrates two types of moderating factors between the use of ICT and level of SCI: (1) ICT-related factors as an enabler of SCI, and (2) other factors as an enabler of SCI. Solely reinforcing ICT capabilities of a firm to assure a more higher level of SCI might not be successful since absence of industry standards, lack of open information-sharing environment, adverse institutional pressures and organizational culture, and lack of involvement of top management could offset the technical side. Although business-IT strategic alignment was not included among other factors due to the lack of an emphasis in the papers, external integration, internal integration, and cross-domain integration could be essential contingencies that would affect the success of ICTs in supply chain integration (Gerow et al., 2014).

The first factor among technological factors is the suitability, criticality, and maturity of ICT, and their fit to an organization's structure and its relationships with SC partners. There is a significant connection link between the depth and requirements of collaboration across supply chain, and suitability and criticality of the technological approach as well as maturity of current technologies to support this collaboration (Pramatari, 2007). The type of ICT and its characteristics as well as ICT customization would influence the suitability, criticality, and maturity of ICT utilized by an organization. Firms can customize their IT to strengthen their competitive positioning to enhance their cooperative strategic information flows (Klein et

al., 2007). In this regard, ICTs which could also align with other enabling factors such as organizational culture could have a mitigating effect on the SCI failures. Companies should take into consideration the suitability and criticality of ICTs, and their alignment with business objectives as well as organization's culture and structure, and involvement of top management in order to reduce the resistance of coworkers and to accelerate the maturity of ICT. Besides internal organizational structure and strategy alignment, IOS integration should be embedded in the strategies and goals of partnering organizations in order to maximize benefits for all member across supply chain (Rajaguru and Matanda, 2013).

ICT capabilities of an organization enhance the effectiveness of ICT on SCI. ICT's vital role as a valued and rare capability ensures SC collaboration (Fawcett et al., 2009). Some of the capabilities and resources required include flexible IT infrastructure, architecture flexibility, technological complementary, managerial IT knowledge, technical and technological capabilities, IT investment, and other IT resources (Lin, 2014; Liu et al., 2016; Sahaym et al., 2007; Richey et al., 2012; Tafti et al., 2013). Integrated IS capability would have a direct effect on firm performance (Bharadwaj et al., 2007). Firms which seek to enhance their SCI with suppliers and customers should prioritize these capabilities in order to maximize the benefits of utilizing ICT as an enabler of ICT. As it is the case for other ICT-related factors, merely having IS capabilities do not lead to better firm performance although IS integration has a moderating effect in the relationship between ICT capabilities and business performance (Gonzalvez-Gallego et al., 2015).

ICT integration was discussed in the literature although it was usually utilized as a mediating or moderating variable towards achieving SCI by means of enhanced exploitation of ICT among supply chain partners as an interorganizational information system (IOS). This factor as an enabler of SCI consisted of information sharing, exchange, and/or integration, Internet-enabled SCI, SC information integration, IOS integration, IT infrastructure integration, SC connectivity, technical integration, real-time SC information integration, and data driven visibility (Jayaram and Tan, 2010; Liu et al., 2010; Fawcett et al., 2011; Basole and Nowak, 2016). IOS integration needs to be embedded in the strategies and goals of partnering organizations so as to maximize benefits for all SC members (Rajaguru and Matanda, 2013).

Another factor is technological differences among available ICT applications with respect to the functionality, type of data, storage, and rendering of data that could hinder integration by creating operational supply chain challenges (Buijs and Wortmann, 2014). Technological differences which may cause ineffective communication among ICTs with distinct functionalities, despite the need for interdependency, either within the company or with supply chain partners, should be reflected in the IT governance strategies and planning by the companies. Availability of industry standards might stipulate the installation of ICTs to have compatible hardware and software features across the industry. However, in the absence of this kind of standards, companies would need to take initiatives themselves which will impose additional costs on the company.

Limitations and Future Research

The search process was designed in accordance with a structured literature review, and authors put considerable effort into the search process. However, it is possible that relevant papers were overlooked and could not be included in the paper pool. For example, some papers may not use the search keywords in their topics or abstracts; therefore, were not captured by our keywords. In addition, our keywords did not include any specific ICT such as RFID, EDI, ERP, etc. Therefore, some of them may not have been identified and included. Furthermore, our research and analysis only covers papers from year 2007 to 2017. All these limitations open the door for future research that is more refined and broader in scope.

As an example of future research, the global impact (or at least involvement of two countries) of supply chain management stood out in 29% of the papers whereas 49% of the studies did not extend beyond one country. Hence, areas with potential for future research will be: ICT integration within the organization and with global SC partners, ICT systems within a multinational organization, and with partners across other countries.

Conclusion

This meta-research investigated the role of information and communication technologies in the supply chain integration by examining 55 papers published in 34 journals between 2007 and 2017. Our research revealed that the relationship between ICTs and SCI has been examined in an average of four paper per year. Since the prevalence and importance of ICTs persist and their worldwide proliferation is expected to increase, research should focus not only in developed countries, but also include less-developed countries to observe whether trends and patterns differ in those countries as compared to developed countries. Our study has also demonstrated the underutilization of theories in the examination of relationships between ICTs and SCI. In terms of research methods, there is a preponderance of the positivist approach and the survey method; research methods should be extended to include and case studies along with other research methods in order to achieve rigor and triangulation. Our study also pointed out the underutilized IS types which researchers could investigate in future research. Finally, we have proposed a research framework as a basis for future research to investigate ICT's role on SCI.

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(Due to publication page limits some references are not include herein. For the full set of references go to http://abdullahoguz.weebly.com/references-for-amcis-2018-paper.html.)

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