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Mobile Supply Chain Management: Moving Where?

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Abstract

We present a state-of-the-art on mobile supply chain management (mSCM). A total of 36 articles were analysed using a systematic review process to classify current knowledge, identify trends, and propose recommendations for future research. Three main categories of papers are identified, namely (1) technical, (2) managerial, and (3) domain-specific. We concluded that mSCM is moving towards a complex combination of technologies and models. Moreover, data shows that the managerial and domain-specific aspects of mSCM have received less attention when compared to the technological perspective. Presently, cloud computing, augmented reality, and the Internet of things seem to be three of the topics with the most potential for research in the area of mSCM. As the vision of Industry 4.0 and the digitalization of global markets makes mSCM a priority for organizations worldwide, our recommendations can assist researchers to address some of its crucial socio-technical challenges.

Keywords: mSCM, Mobile Supply Chain Management, Mobile Technologies, Systematic Literature Review.

1 INTRODUCTION

The industry of the future will demand data acquisition and sharing throughout the supply chain (Brettel & Friederichsen, 2014). This vision for interconnected business services, processes, and information systems (IS), is possible due to exceptional technological developments, especially mobile (Bharadwaj et al., 2013). Yet, these technologies are not useful to companies without systems that support them and without the knowledge on how people use and adapt them (Sanakulov & Karjaluoto, 2015; Paul, 2007). In this paper, we address the emerging results from combining supply chain management and mobile technologies.

Brettel and Friederichsen (2014) identified different research streams for the fourth industrial revolution (Industry 4.0). On the one hand, they recognize the priority for establishing collaborative networks, supply chain visibility, simultaneous planning of products and processes, and supply chain flexibility. On the other hand, the structure of Industry 4.0 involves cloud computing, Internet of things (IoT) and services, individualized traced data, real-time operating systems, virtualization of the process chain, and end-to-end digital integration.

Supply chain management (SCM) can be defined "*as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*" (Mentzer et al., 2001, p.18). SCM involves collaboration between the firm, its customers, and suppliers (Casadesús & Castro, 2005), different flows of products and informational objects (Mentzer et al., 2001).

Supply chain coordination requires that actors share information and synchronize the decisions to link the processes involved (Simatupang et al., 2004). Coordination, operational planning, and strategic planning, supported by information and communication technologies, have the potential to reduce operational costs and improve customer service (Thomas & Griffin, 1996). There are other SCM practices that have a positive impact on operational performance, including just-in-time supply, managing and coordinating suppliers, holding safety stocks, and strategic collaboration on machinery and equipment industry (Koh et al., 2007).

Mobile supply chain management (mSCM) (Eng, 2006) emerges as a central topic for Industry 4.0. Moreover, it should be a priority for information systems (IS) research, a field that addresses technical and social aspects that emerge in the use and adaptation of IT and organizational processes (Paul, 2007).

There are social and technical issues involved in successful mSCM, that refers to "*the use of mobile applications and devices to aid the conduct of supply chain activities, and ultimately help firms to gain cost reductions, supply chain responsiveness and competitive advantage*" (Eng, 2006, p.682). It is suggested that companies adopt a process approach, to promote interaction among the mSCM participants, and, supported by mobile technologies, share resources to increase trust and commitment (Eng, 2006). However, mobile technology adoption also raises paradoxes, as described by Jarvenpaa and Lang (2005), who provide system design options to address them. According to Jarvenpaa and Lang (2005, p.21) "*users engage in closer and more personal relationships with mobile technology than with other forms of IT*" and additional research is required to foster mobile technologies in SCM problem solving and effective user interaction. An ERP is not enough for mSCM (Ketikidis et al., 2008). There are different technologies available, for example RFID (radio frequency identification), GPS (global positioning system), and wireless technologies, with identified benefits for product tracking, efficiency in information processing, enhanced security, reducing counterfeit products, improved customer relations and control of supplies (Ketikidis et al., 2008).

Several authors have studied mSCM. However, as stated by Nysveen et al. (2015), few articles considered the mobile services for real-time supply chain coordination. According to Nysveen et al. (2015, p.7), "*only a few articles discuss mobile services related to the business-to-business context. Examples of such services are Real time supply chain coordination and Mobile e-procurement services*". Our contribution to mSCM is in the form of a systematic literature review (Webster & Watson, 2002; Tranfield et al., 2003; Kitchenham, 2004; Okoli & Schabram, 2010; Levy & Ellis, 2006) to identify current knowledge and opportunities to advance the body of knowledge further.

We organized the remainder of the paper as follows: in the next section we present the method used for our systematic literature review of 36 papers in the scope of mSCM. In section 3 we present the findings according to three focal categories, namely (1) technical, (2) managerial, and (3) domain-specific. A discussion of the results is offered in Section 4, suggesting directions for future research in mSCM. In Section 5 we offer some conclusions and state limitations of our research.

2 METHOD

Our systematic literature review was designed according to the guidelines of Webster and Watson (2002), Tranfield et al. (2003), Kitchenham (2004), Okoli and Schabram (2010), and Levy and Ellis (2006).

Systematic literature reviews analyse the past to prepare the future (Webster & Watson, 2002), uncovering the body of knowledge by identifying, evaluating, and interpreting research [primary studies] that is relevant to a specific topic area (Kitchenham, 2004). Several researchers, for example Webster and Watson (2002) or Levy and Ellis (2006), called for more systematic reviews in IS research, and there is specific guidance for IS researchers to conduct this type of studies. For example, Webster and Watson (2002) propose the concept-centric approach for classification of articles, suggest backward searches reviewing citations of relevant articles, and forward searches to identify the ones citing them. On the other hand, Kitchenham (2004) and Okoli and Schabram (2010) provide a detailed sequence of steps to conduct systematic reviews, namely to (1) identify the need for the research, (2) establish a review protocol, (3) search the literature, (4) study selection and screening, (5) quality assessment, (6) data extraction and monitoring, (7) data synthesis, and (8) write the review. Other authors, such as Levy and Ellis (2006), provide practical examples in the IS field on how to find valid IS sources and how to read, annotate, and present the literature review.

In Okoli and Schabram (2010), the authors present a distinction between systematic and other conventional forms of literature reviews. These authors identify the two most conventional forms of reviews, namely, the *thesis literature review* in the form of a chapter, and the *theoretical background*, to provide the foundations and focus for a specific study. Another distinct form is the *stand-alone literature review* "*a journal-length article whose sole purpose is to review the literature in a field* […and when] *is conducted using a systematic, rigorous standard, it is called a systematic literature review*" (Okoli & Schabram, 2010, p.2). Literature reviews are essential for academics and for practitioners, as described by Tranfield et al. (2003, p.220), "*the aim of systematic review is to provide collective insights through theoretical synthesis into fields and sub-fields. For academics, the reviewing process increases methodological rigour. For practitioners/managers, systematic review helps develop a reliable knowledge base by accumulating knowledge from a range of studies*".

Two researchers participated in this literature review. First, one of the researchers conducted a preliminary search for publications addressing Supply Chain and Mobile Technologies in EBSCO, ScienceDirect, IEEE, Google Scholar, and Mendeley. The search space included journals and conferences, with no time restriction. Specific books were considered, for example, Sathyan et al. (2012) and Li (2006), even if not included in the literature coding, due to the variety of topics included in their work. Given the generic nature of the terms "supply chain management" (375000 matches obtained in Google Scholar in 05-03-2016) and "mobile technologies", the search keywords were combined by boolean operators (e.g., "information systems" + "supply chain" + "mobile technologies" with the 4090 matches in Google Scholar, dropping to 1300 if restricted to more recent than the year 2012).

The initial insights were discussed by the research team to decide on more precise keywords. We then focused our review on the terms "mobile supply chain management" and "mSCM". There are differences in the results from each database. For example, Mendeley returns 10 papers for "mobile supply chain management", however, Eng (2006) appears twice and Chan and Chong (2013) appear three times in that list. The same keyword sequence leads to 245 results in Google scholar – which partially covers other search engines –, 43 in EBSCO, and 8 in ScienceDirect. Nevertheless, we found benefits in probing multiple sources of data because it (1) strengthened our evidences about the most relevant indexed publications, and (2) allowed us to evaluate the same contribution at distinct moments in time, contrasting the findings with previous reflections about the topic and other related documents. At this phase, we screened 245 titles and abstracts that included mobile technologies for supply chain management.

Next, backward and forward searches were performed for each relevant article, according to the guidelines provided by Levy and Ellis (2006) and Webster and Watson (2002). Backward searches included the sub-steps of backward references search, for example the work of Eng (2006) cited in Tomislav et al. (2014) and Chan and Chong (2013), backward authors search (e.g., Giaglis et al. (2002) and Giaglis et al. (2004)) and keywords (e.g., RFID is a popularly cited term in our sample). Forward searches included other articles that have cited the initial paper set and additional work published by identified authors. We made searches for specific technologies that we have found in the most relevant papers identified in previous phases of the review, namely "RFID" and "smartphones". For example, the combination "supply chain" + mobile + RFID + smarthpone + tablet, which returned 769 matches in Google Scholar (601 when restricting above the year 2012). Examples of other combinations tested where "mobile supply chain management" + adoption + model (114 matches in 05-03-2016, 37 since 2012); "mSCM" + "mobile" + "supply chain" (77 matches in 07-03-2016, 23 since 2012); "information systems" + "mobile supply chain" (238 matches in 07-03-2016, 70 since 2012). In this phase, our inclusion criteria addressed the mobile technologies presented above and its possible integration in supply chain management (Mentzer et al., 2001; Eng, 2006).

The 36 most relevant publications were tagged and annotated using the Mendeley free reference manager tool. We used Mendeley to perform additional keyword search in the full text of the articles, with the aim of identifying if/how specific words were mentioned by the authors. For example, the term "cloud" appears in 5 of the 36 papers (14%), however, only 2 of them (6%) focus on cloud in mSCM (Grzybowska et al., 2014; Srinivasan & Dey, 2014), the others merely mention the importance of the general concept. It is recommended to classify each paper in themes or categories to portray their contribution (Webster & Watson, 2002) and we can find several systematic reviews adopting this procedure. For example, in MISQ, Chen et al. (2010) classified three main categories of IS strategy from the systematic review of 48 papers, while Leidner and Kayworth (2006) observed six categories in the literature of culture and IS. The three main categories that we found in the mSCM literature are presented in the next section.

3 MAKING SENSE OF THE LITERATURE REVIEW

We classified the papers according to their most prevalent category, namely (1) Technical, (2) Managerial, and (3) Domain-specific. In the first category we included studies that describe the mobile technologies available for mSCM and their benefits / opportunities. Examples of the mSCM technologies are RFID (Meydanoğlu & Klei, 2013), smartphones (Szymczak, 2013), and GPS (Giaglis et al., 2002). The second category of papers present models and frameworks, for example, to evaluate mSCM adoption (Rathore & Ilavarasan, 2014) and the process of evolving mSCM in organizations (Basole, 2005; Pousttchi & Gumpp, 2005). Finally, we identify studies addressing specific sectors of the economy (Nourbakhsh, 2012) or activity areas (Lu et al., 2006), where authors discuss both, technical and managerial models, for selected activity sectors. Figure 1 presents the paper distribution according to the three identified categories of mSCM publications.

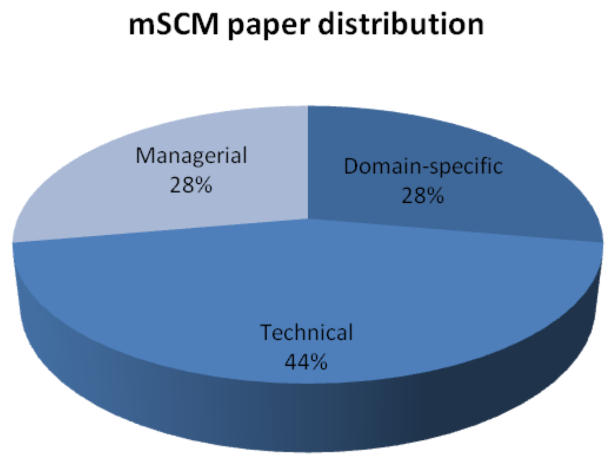

Figure 1. Distribution of the 36 mSCM papers across the 3 categories.

The majority of the analysed studies address technical aspects of mSCM, reaching 44%. Twenty-eight percent of the publications fall into the category concerned with managerial aspects of mSCM, which includes models and frameworks, and domain-specific applications of mSCM. Conceptual studies are more frequently found (61%) when compared with the empirical ones (39%).

We performed a full text search analysis to identify specific technologies and platforms. The keyword "wireless" can be found in 25 of the 36 studies (69%), while smartphones/PDA/Tablet occur in 21 (58%), RFID in 19 (53%), and GPS and combinations of GPRS/3G/GSM in 16 (44%). Platforms such as ERP are mentioned in 19 of the selected papers (53%). Curiously, cloud was only mentioned in 5 (14%) of the papers, "Internet of things" in 3 (8%), and "augmented reality" in 1 (3%). However, when we deepen the analysis and exclude the papers that only make superficial mentions to the concepts (e.g., "cloud" is mentioned in 5 studies but only 2 of them include it in their contributions), then the results are considerably different as presented in Figure 2.

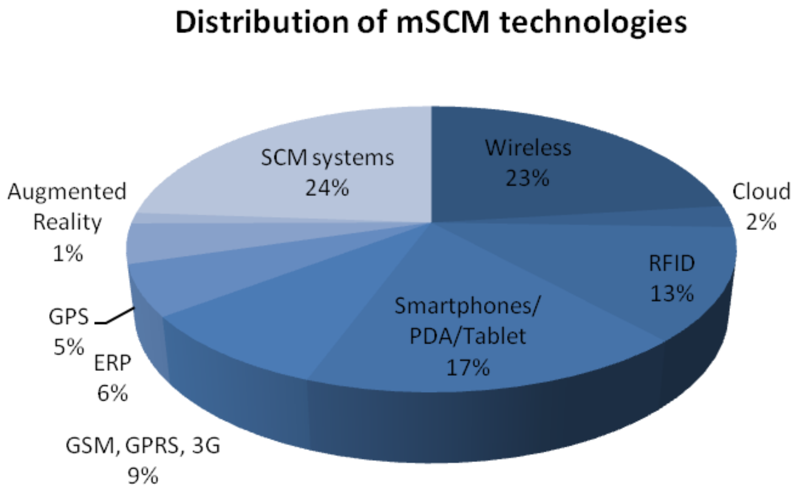

Figure 2. Distribution of mSCM technologies in the 36 studies.

The majority of technological papers (24% of 36) focus mSCM systems, not a specific technology. Wireless solutions, at 23%, comes second, followed by the use of smartphones, PDAs or tablet devices on mSCM. Still with two digits, there is RFID (13%), followed by the telecommunication protocols (9%), ERP (6%), GPS (5%) and, the less studied, cloud, with a scarce 2% and augmented reality with 1%.

In the next sections we further detail the review in the three identified categories.

3.1 Technical

The technical outlook for mSCM can be found in studies such as Yuan et al. (2008), that present programming languages and standards (e.g., XML), mobile phone technologies (e.g., 3G and GPRS), and communication protocols such as WAP and Bluetooth. The authors propose a conceptual structure for an mSCM platform and conclude with examples for different activities of the supply chain, for example, mobile shipment and mobile sale.

The potential of going mobile is transversal to all supply chain activities. There are examples of solutions for each activity of the value chain as presented by Barnes (2002), which focused the business-to-business interaction of the supply chain. Conversely, the review of technologies and future research proposals made by Siau and Shen (2002) concentrated on mobile commerce activities with customers and suppliers. The focus of business-to-consumer was also selected by Markova and Petkovska-Mircevska (2013) to explore the potential of social networks for mSCM.

There are examples internal and external to the organizational boundaries. Internal application cases are provided by Groger and Stach (2014), which present a dashboard for mobile manufacturing, accessible to shop floor workers and production supervisors, while Stefan and Kerins (2014) present a practical application of web services and PDA adoption for maintenance management processes. One external example is accessible by the diffusion of mobile marketing and its success factors presented by Scharl et al. (2005), proposing a model for SMS advertising. Another case is presented by Grzybowska et al. (2014), who show how cloud computing and service oriented architecture (SOA) can assist mSCM implementation in freight and warehouse exchanges.

RFID is a popular area of research in the scope of supply chain management. Mobile RFID is made possible by the use of mobile devices embedded with micro RFID readers, as presented by Meydanoğlu and Klei (2013). These authors discuss potential advantages of RFID in distinct SCM areas, including different supporting technologies for physical mobile interaction, such as NFC (Near Field Communication), 2D codes, and QR codes. There are opportunities to jointly implement RFID in the supply chain, but the costs are significant. The method developed by Irrenhauser and Reinhart (2014) allows the evaluation of economic viability of RFID implementations. This technology has been and continues to be a popular research stream in mobile SCM. Other authors, such as Miraldes et al. (2015), studied RFID and emergent technologies of augmented reality in mSCM.

There are several areas in the supply chain context where smartphones can be used. According to Szymczak (2013), examples include the two most usual applications of scanning bar codes and exchanging photos of products, but there is an increasing interest in adopting smartphones for proof-of-delivery signature, access to dashboards and specific reports, control machinery in industrial settings (Mathew et al., 2006), and social networking. Nevertheless, human computer interaction is a major challenge in the use of these devices, and there are social aspects to take into consideration. For example, a study presented by Müller et al. (2012) suggests that, presently, the main use of tablets is for personal purposes. According to these authors, it is necessary to (1) improve application design for these devices, (2) conduct studies to promote an integrated experience across all types of devices, and (3) understand the social impact of using this type of devices.

Another perspective is the indoor *vs.* outdoor use of technology. Giaglis et al. (2002) present one of the few studies addressing indoor mobile positioning, and present a taxonomy for different indoor/outdoor positioning technologies, including Cell-ID, Time of Arrival (TOA), Observed Time Difference (OTD), GPS and A-GPS, Infrared sensors, Ultrasound technologies, Wireless LANs (WLANs), Bluetooth, RFID, and Indoor GPS. The authors include mSCM in the B2B solutions category and point to examples of goods tracking and continuous replenishment. In a later study, Giaglis et al. (2004) addressed logistics and vehicle routing. The authors classified relevant literature in the field of vehicle routing problem and propose an architecture for real-time vehicle management with mobile technologies, integrated with a decision support system.

Ruhi and Turel (2005) present a review and a taxonomy of mobile technologies in different areas of the supply chain. It includes the internal supply chain (involving internal customers and suppliers), inbound logistics (supplier relations) and customer relations including outbound logistics, marketing, sales, and services. Examples are presented for the distinct areas and drivers (e.g., internal and external integration, globalization, data information management, new business processes, replace obsolete systems, and strategic cost management) and difficulties (e.g., interoperability between mobile devices and mobile standards). In spite of the technological focus, authors conclude that "*case studies investigating the undertakings of these organizations [implementing mSCM] and their experiences with different technologies can provide valuable insights for revising and improving the research exposition*" (p.14).

A managerial lens was selected for their studies by other authors, as presented in the next section.

3.2 Managerial

There are contributions for different phases of the mSCM lifecycle: adoption, coordination, integration, and diffusion. Eng (2006) examined three critical areas of SCM for successful implementation of mSCM, namely, competitive advantage, customer relationship management, and coordination and integration. The author argues that the likelihood of successful mSCM will be enhanced by (1) the adoption of a process approach to interact with other participants in the supply chain, (2) sharing resources, which can lead to an increase in trust and commitment, and (3) "*cross-functional knowledge of disparate supply chain functions and activities, because higher coordination and integration success in mSCM depends on embedded knowledge of systems*" (Eng, 2006, p.686).

3.2.1 Adoption

Pan et al. (2013) propose a model to adopt mSCM. It was based on a survey involving 168 executives and managers in the retail industry. The authors conclude that pressures from other stakeholders in the supply chain have an influence in the adoption of mSCM. Top management support and long term relationships are two additional factors that can influence mSCM adoption intention. Shared workshops and training programs to communicate the strategy of the supply chain and shared projects "*may help built inter-organization trust and inter-organization dependence*" (p.184). The authors argue that "*although mobile-enabled supply chain management systems (mSCM) are still in the early development stages, they have the potential to elevate supply chain integration to a higher level beyond what the internet-enabled supply chain management systems (eSCM) have already provided*" (p.172). Pousttchi and Gumpp (2005) introduce the "Mobility-M"-framework for application of mobile technologies at process level. One of its pillars includes mobile infrastructure, communication techniques, and devices to achieve mobile added value. The other pillar concerns the information added value with systems such as SCM, Customer Relationship Management (CRM), administration, operations, and Business Intelligence (BI).

Other authors focus on the main services provided by mobile technologies in the entire supply chain. For example, Li et al. (2010) suggest mobile data collection, location-based services, scheduling, voice calls, and information dissemination. There are distinct elements to consider for the mobile enterprise, for example, the transition from non-mobile to mobile, the value, and best practices to transform the enterprise with mobile technologies (Li, 2006). A long term vision is required for that transformation and it starts with (1) the mobilization to use IS in mobile, continues with (2) the enhancements of mobile services and applications, (3) the reshipment of business models and strategies, and concludes with (4) the redefinition of new core competencies in the organization (Basole, 2005).

3.2.2 Coordination

Soroor et al. (2009) present a model for mobile real-time supply chain coordination system. The authors highlight limitations of deploying mobile communications for supply chain coordination from methodological, architectural, and technical viewpoints. Methodological perspective requires that information delivery should not be static and must take into consideration the change in people's context and supply network conditions that occur in mobile. Regarding architectural aspects, the authors mention the lack of integration between mobile applications and the organizational ICT infrastructure, and also inflexibility problems. According to the authors "*most of the commercially available mobile applications for use in real-time coordination of supply networks are designed primarily for internal off-line use*" (Soroor et al., 2009, p.637). Finally, according to the technical perspective, there is a lack of studies that include emerging technologies such as Semantic Web, Web Services, agents, and context aware computing. Soroor et al. (2009) propose an Intelligent Wireless Web (IWW) model and present an implementation scenario. The model uses contextual information of the connected user to provide the relevant information.

3.2.3 Integration

mSCM integration may involve strategies of packaging customization, common use of equipments, or shared services, but information systems have an increasing impact in this field, for example with the knowledge of inventory, shared planning systems, and joint networks (Frohlich & Westbrook, 2001). Shah et al. (2002) studied inter-organizational information systems (IOIS) and proposed a matrix for SCM and IOIS alignment. The matrix includes four levels of SCM adoption, namely the arm's length level for simple exchange relationships (lowest level), Type I – short term relationship, Type II – long term relationship, and the most advanced Type III – coordination, when companies consider other firms as extensions of their own business. There are also four levels of IOIS adoption, starting with no electronic integration, then a sequence of low, medium, and high level of electronic integration between the business and the supply chain partners. Srinivasan and Dey (2014) used the potential of cloud computing for the integration of ERP and SCM systems, proposing a framework for electronic supply chain enabled by mobile technologies.

3.2.4 Diffusion

A model to evaluate mSCM diffusion in manufacturing companies is presented by Chan and Chong (2013). These authors considered three phases of mSCM diffusion, namely (1) evaluation, (2) adoption, and finally (3) routinisation (Chan & Chong, 2013). The model was inspired on the on the technology–organisation–environment framework and innovation diffusion theory, including four main factors that affect mSCM diffusion: technological, organizational (internal to the company), environmental (company context), and inter-organizational relationships. More recently, Rathore and Ilavarasan (2014) conducted 14 interviews and 47 questionnaires in SMEs operating in the automobile industry. The authors identified a group of factors that affect the intensity of mSCM adoption aligned with Chan and Chong (2013), namely technology-environment (e.g., competitive pressure), information quality (e.g., accuracy), organizational (e.g., top management support), and partners (e.g., mobile readiness). Moreover, the authors found that, in their sample, the most important motives to adopt mSCM are cost reduction, ease of use, improved partner coordination, and cooperation for new product development.

The next section reviews articles addressing vertical domains of the economy, providing detailed guidance for specific contexts of mSCM.

3.3 Domain-specific

There are studies addressing mobile technologies in specific sectors, for example, the impact in healthcare service delivery (Free et al., 2013) and potential applications by pharmacies (Clauson et al., 2013). Nourbakhsh (2012) studied mobile adoption in construction, and identified key information requirements from the perspectives of consultants, contractors, and clients. Salo (2012) presents a case study in the steel industry. The study highlights the importance of mobile technologies to improve internal/external coordination and to cut costs of interfacing processes between customers and suppliers. Interestingly, mobile technologies allow redesigning business processes while thinking about the context of information use. Maintenance in the mining industry adopting RFID is the focus of Atkins et al. (2010). An example of a commercial application in the hospitality industry is presented by Tomislav et al. (2014).

Other authors selected a specific technology and detailed its domain-specific application. The adoption of RFID in manufacturing has been studied by Lu et al. (2006), which proposed a five-step deployment approach for its implementation in manufacturing companies. Prater et al. (2005) selected the context of the grocery retailing to suggest three main areas of future research for RFID, namely modelling RFID-based supply chains, RFID implementation, and its daily operation.

A set of different case studies for enterprise mobility in New Zealand is presented by Scornavacca and Barnes (2008), including mobile supply chain applications for wireless field force automation and wireless sales force automation. The authors describe cases of three companies in the food industry, two trade services organizations, and a real-estate company.

4 Discussion

Our sample included 44% (16) of papers addressing technical aspects of mSCM. A significant majority of those papers (73%) are conceptual, identifying the technologies and its possible applications but lacking empirical evidence. The prevailing perspective of technical publications is to identify and describe technologies, their possible applications, and benefits – e.g., Szymczak (2013); Barnes (2002) –, but lacking answers for "how to select mobile technologies", "comparison of mobile devices for specific purposes of mSCM", "the impact of mobile technologies in the redesign of inter-organizational business processes" (Legner & Wende, 2007).

RFID, mSCM solutions, and mobile devices, such as smartphones, tablets, or PDAs, are the most cited technologies to achieve SCM mobility. However, the current trend in Industry 4.0 points to the priority of cloud computing, augmented reality, and IoT (Brettel & Friederichsen, 2014), scarcely studied in mSCM area. Interestingly, some studies such as Prajogo and Sohal (2013) point out that the benefits of information and communication technologies are not yet sufficiently recognized, and that the level of IT adoption in the supply chain is still low. This opens up further opportunities for research in mobile IT adoption. It will also be interesting to study the impact of modern paradigms such as cloud and IoT in the need to balance security and trust in supply chain cooperation, relying in inter-organizational business processes and requirements of data sharing. Data quality and a comprehensive IS quality culture (Barata et al., 2013) are also potential areas of future research in mSCM.

Regulatory compliance is a central issue in IS design (Bonazzi et al., 2010). However, in our review, we did not find domain-specific studies addressing the role of mSCM to assist compliance in critical sectors, such as the food chain, that represents a priority in Europe (European Commission, 2009). Traceability of food and original products can be supported by mSCM due to the proper identification of products and its components along the entire supply chain, opening opportunities for future research.

Furthering the study by Chan and Chong (2013) about mSCM diffusion, there is an opportunity to develop maturity models (Becker et al., 2009) for mSCM, assisting companies in the diffusion process, including social and technical aspects of mSCM maturity. For example, using matrices as suggested by Loebbecke et al. (2013) for cloud readiness at Continental AG. These authors found that compliance is one of the main problems for the migration of IT services for the cloud, so it could be interesting to make the parallel analysis regarding mSCM.

There is a lack of empirical-qualitative studies in mSCM. While there are examples of case studies using mobile technologies in companies (Sheng et al., 2005), they do not address mSCM nor explain how companies of specific sectors can manage mSCM lifecycle adoption, at design-time and at run-time. We did not find any cases using design science or action research approaches to study mSCM. A lack of empirical-qualitative studies was also identified by Nysveen et al. (2015), which reviewed 212 articles in the context of mobile services and mobile apps. In their study, 60% of the articles were empirical-quantitative (mostly surveys, regarding mobile service adoption but also including quantitative-econometric), 31% conceptual, and only 9% empirical-qualitative.

Mobile technologies enable access information when and where it is needed. Moreover, they enable the existence of individual information systems that coexist with organizational information systems (Baskerville, 2011). This means that, on the one hand, it is possible to provide information along the entire supply chain. On the other hand, it is also possible to adapt mSCM information to the context of the user (Gross & Specht, 2001), fostering solutions in context-aware mSCM.

Social aspects are insufficiently studied in mSCM. For example, the impact of mobile technologies in work conditions (e.g., safety, ergonomics), the permanent interaction with customers and the impact in their satisfaction, approaches and frameworks to assist managers and workers in their transition for mobile enterprise.

5 CONCLUSIONS

We presented a systematic literature review of 36 papers about mobile supply chain management (mSCM). The sample included journals and conferences. In 44% of the identified papers, the technical perspective is dominant. There is a balance between the managerial and domain-specific categories of studies, representing 28% each.

The majority of technical papers is conceptual, addressing diverse technologies, for example, RFID and tablet adoption in the supply chain. Few mSCM studies addressed emerging trends for Industry 4.0, namely cloud, augmented reality, and IoT. Managerial papers include models and frameworks of adoption, coordination, integration, and diffusion of mSCM. Additional research is needed to focus on social aspects of mSCM adoption, for example, in inter-organizational process design and in regulatory compliance. Domain-specific papers combine technical and managerial issues. There is a need to conduct more empirical-qualitative studies to deeply understand critical supply chains of our society, for example, food and healthcare.

It is worthwhile stating a number of limitations of our paper. First, despite the care taken, the selection of databases and keywords influences the results that we have obtained. Second, we restricted our search to papers addressing mobile supply chain management as defined by Eng (2006). Third, due to the scarce publications mentioning mSCM, we did not filter the sources, so the quality of the various papers can differ. Forth, although we present quantitative results from the findings, the trends of future research are merely indicative and emerge from the critical assessment of the papers collected.

Our study contributes to the industrial practice by developing a knowledge base (Tranfield et al., 2003) of (1) mobile technologies for mSCM, (2) managerial aspects involved in mSCM, and (3) solutions that can be applied in specific domains. mSCM should be a priority for managers that include the emerging forth industrial r(evolution) in their agenda. The reason is that mSCM addresses key priorities of Industry 4.0 that Brettel and Friederichsen (2014) classify, such as end-to-end digital integration, supply chain visibility, and management of collaborative networks.

This literature review suggests future research avenues accessible in the discussion section. We already planed our next step to perform an action research project for mSCM development in a leading supplier of ceramic powder in Portugal. The supply chain includes several mineral extraction sites, transformation plants, and a complex logistic structure for quality control, distribution, and sales.

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References

Atkins, A., Zhang, L. & Yu, H. 2010. 'Application of RFID and Mobile technology in Tracking of Equipment for Maintenance in the Mining Industry'. *The Australasian Institute of Mining and Metallurgy*, (1), pp.350–358.

Barata, J., Cunha, P.R. & Costa, C.C. 2013. 'The Foundations for an IS Quality Culture in the Context of ISO 9001'. In *Proceedings of the 10th European, Mediterranean and Middle Eastern Conference on Information Systems (EMCIS)*. Windsor, UK.

Barnes, S.J. 2002. 'Unwired Business : Wireless Applications in the Firm ' s Value Chain'. In *Proceedings of the Pacific Asia Conference on Information Systems (PACIS)*. Tokyo, Japan, pp. 932–944.

Baskerville, R. 2011. 'Design Theorizing Individual Information Systems'. In *Proceedings of the Pacific Asia Conference on Information Systems (PACIS)*. pp. 1–12.

Basole, R. 2005. 'Transforming enterprises through mobile applications: a multi-phase framework'. In *Proceedings of the Americas Conference on Information Systems (AMCIS)*. pp. 1935–1939.

Becker, J., Knackstedt, R. & Pöppelbuß, J. 2009. 'Developing Maturity Models for IT Management'. *Business & Information Systems Engineering*, 1(3), pp.213–222.

Bharadwaj, A. et al. 2013. 'Digital Business Strategy: Toward a Next Generation of Insights'. *MIS Quarterly*, 37(2), pp.471–482.

Bonazzi, R., Hussami, L. & Pigneur, Y. 2010. 'Compliance management is becoming a major issue in IS design'. In A. D'Atri & D. Saccà, eds. *Information Systems: People, Organizations, Institutions, and Technologies*. Heidelberg: Springer, pp. 391–398.

Brettel, M. & Friederichsen, N. 2014. 'How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective'. *International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering*, 8(1), pp.37–44.

Casadesús, M. & Castro, R. 2005. 'How improving quality improves supply chain management: empirical study'. *The TQM Magazine*, 17(4), pp.345–357.

Chan, F.T.S. & Chong, A.Y.-L. 2013. 'Determinants of mobile supply chain management system diffusion: a structural equation analysis of manufacturing firms.'. *International Journal of Production Research*, 51(4), pp.1196–1213.

Chen, D. et al. 2010. 'Information Systems Strategy: Reconceptualization, Measurement, and Implications'. *MIS Quarterly*, 34(2), pp.233 – 259.

Clauson, K. et al. 2013. 'Opportunities for pharmacists in mobile health'. *American Journal of Health-system Pharmacy*, 70(15), pp.1348–1352.

Eng, T.-Y. 2006. 'Mobile supply chain management: Challenges for implementation'. *Technovation*, 26(5-6), pp.682–686.

European Commission 2009. *A better functioning food supply chain in Europe*, Brussels.

Free, C. et al. 2013. 'The Effectiveness of Mobile-Health Technologies to Improve Health Care Service Delivery Processes: A Systematic Review and Meta-Analysis'. *PLoS Medicine*, 10(1).

Frohlich, M.T. & Westbrook, R. 2001. 'Arcs of integration: An international study of supply chain strategies'. *Journal of Operations Management*, 19(2), pp.185–200.

Giaglis, G.M. et al. 2004. 'Minimizing logistics risk through real-time vehicle routing and mobile technologies: Research to date and future trends'. *International Journal of Physical Distribution & Logistics Management*, 34(9), pp.749–764.

Giaglis, G.M. et al. 2002. 'On the potential use of mobile positioning technologies in indoor environments'. *15th Bled Electronic Commerce Conference. eReality: Constructing the eEconomy*, pp.413–429.

Groger, C. & Stach, C. 2014. 'The mobile manufacturing dashboard'. In *2014 IEEE International Conference on Pervasive Computing and Communication Workshops (PERCOM WORKSHOPS)*. IEEE, pp. 138–140.

Gross, T. & Specht, M. 2001. 'Awareness in Context-Aware Information Systems'. *Mensch & Computer - 1. fachübergreifende Konferenz*, 1, pp.173–182.

Grzybowska, K., Kovács, G. & Lénárt, B. 2014. 'The supply chain in cloud computing'. *Research in Logistics & Production*, 4(1), pp.33–44.

Irrenhauser, T. & Reinhart, G. 2014. 'Evaluation of the economic feasibility of RFID in the supply chain'. *Production Engineering*, 8(4), pp.521–533.

Jarvenpaa, S.L. & Lang, K.R. 2005. 'Managing the Paradoxes of Mobile Technology'. *Information Systems Management*, 22(4), pp.7–23.

Ketikidis, K.H. et al. 2008. 'The use of information systems for logistics and supply chain management in South East Europe: Current status and future direction'. *Omega*, 36(4), pp.592–599.

Kitchenham, B. 2004. 'Procedures for Performing Systematic Reviews'. *Keele University, Technical Report TR/SE-0401 and NICTA Technical Report 0400011T.1.*

Koh, S.C.L. et al. 2007. 'The impact of supply chain management practices on performance of SMEs'. *Industrial Management & Data Systems*, 107(1), pp.103–124.

Legner, C. & Wende, K. 2007. 'The Challenges of Inter-Organizational Business Process Design - A Research Agenda'. In *European Conference on Information Systems (ECIS)*.

Leidner, D. & Kayworth, T. 2006. 'Review: a review of culture in information systems research: toward a theory of information technology culture conflict'. *MIS quarterly*, 30(2), pp.357–399.

Levy, Y. & Ellis, T.J. 2006. 'A Systems Approach to Conduct an Effective Literature Review in Support of Information Systems Research'. *Informing Science Journal*, 9, pp.181–212.

Li, L., Guo, W. & Wang, Y. 2010. 'Mobile Supply Chain Management: Theory and Method'. In *2010 International Conference on E-Product E-Service and E-Entertainment*. IEEE, pp. 1–5.

Li, Z. 2006. *Enterprise Goes Mobile: A Framework and Methodology for Creating a Mobile Enterprise*, ProQuest.

Loebbecke, C., Thomas, B. & Ullrich, T. 2013. 'Assessing Cloud Readiness at Continental AG'. *MIS Quarterly Executive*, 11(1), pp.11–23.

Lu, B.H., Bateman, R.J. & Cheng, K. 2006. 'RFID enabled manufacturing: fundamentals, methodology and applications'. *International Journal of Agile Systems and Management*, 1(1), pp.73–92.

Markova, S. & Petkovska-Mircevska, T. 2013. 'Social Media and Supply Chain'. *Supply Chain Management*, 15(33), pp.89–103.

Mathew, J. et al. eds. 2006. 'Remote Machine Monitoring Through Mobile Phone, Smartphone or PDA'. In *Engineering Asset Management*. Springer London, pp. 309–315.

Mentzer, J.J.T. et al. 2001. 'Defining supply chain management'. *Journal of Business Logistics*, 22(2), pp.1–25.

Meydanoğlu, E.S. & Klei, M. 2013. 'Commercial Utilization of Mobile RFID'. In *Radio Frequency Identification from System to Applications*. InTech, pp. 245–265.

Miraldes, T. et al. 2015. 'IT Applications In Logistics And Their Influence On The Competitiveness Of Companies/Supply Chains'. *Annals of the Alexandru Ioan Cuza University - Economics*, 62(1), pp.115–140.

Müller, H., Gove, J. & Webb, J. 2012. 'Understanding Tablet Use - A Multi-Method Exploration'. *Proceedings of the 14th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI'12)*, pp.1–10.

Nourbakhsh, M. 2012. 'Mobile application prototype for on-site information management in construction industry'. *Engineering, Construction and Architectural Management*, 19(5), pp.474–494.

Nysveen, H., Pedersen, P.E. & Skard, S.E.R. 2015. *A review of mobile services research: Research gaps and suggestions for future research on mobile apps. SNF Working Paper No 01/15*,

Okoli, C. & Schabram, K. 2010. 'A Guide to Conducting a Systematic Literature Review of Information Systems Research'. *Sprouts Working Papers on Information Systems*, 10(26), pp.1–49.

Pan, Y. et al. 2013. 'Adoption model of mobile-enabled systems in supply chain.'. *Industrial Management & Data Systems*, 113(2), pp.171–189.

Paul, R.J. 2007. 'Challenges to information systems: time to change'. *European Journal of Information Systems*, 16(3), pp.193–195.

Pousttchi, K. & Gumpp, A. 2005. 'The "Mobility-M"-framework for Application of Mobile Technology in Business Processes'. In V. Cremers, A. B.; Manthey, R.; Martini, P.; Steinhage, ed. *Proc. of INFORMATIK 2005*. pp. 523–527.

Prajogo, D. & Sohal, A. 2013. 'Supply chain professionals - A study of competencies, use of technologies, and future challenges' B. Clegg, Jillian MacBryde and Prasant, ed. *International Journal of Operations & Production Management*, 33(11/12), pp.1532–1554.

Prater, E., Frazier, G. V. & Reyes, P.M. 2005. 'Future impacts of RFID on e-supply chains in grocery retailing'. *Supply Chain Management: An International Journal*, 10(2), pp.134–142.

Rathore, A.K. & Ilavarasan, P.V. 2014. 'Mobile Adoption in Collaborating Supply Chains'. In *Proceedings of the 2014 International Conference on Information and Communication Technology for Competitive Strategies - ICTCS '14*. New York, pp. 1–11.

Ruhi, U. & Turel, O. 2005. 'Driving Visibility , Velocity and Versatility : The Role of Mobile Technologies in Supply Chain Management'. *Journal of Internet Commerce*, 4(3), pp.37–41.

Salo, J. 2012. 'The role of mobile technology in a buyer-supplier relationship: a case study from the steel industry'. *Journal of Business & Industrial Marketing*, 27, pp.554–563.

Sanakulov, N. & Karjaluoto, H. 2015. 'Consumer adoption of mobile technologies: a literature review'. *International Journal of Mobile Communications*, 13(3), p.244.

Sathyan, J. et al. 2012. *A Comprehensive Guide to Enterprise Mobility*, CRC Press.

Scharl, A., Dickinger, A. & Murphy, J. 2005. 'Diffusion and success factors of mobile marketing'. *Electronic Commerce Research and Applications*, 4(2), pp.159–173.

Scornavacca, E. & Barnes, S.J. 2008. 'The strategic value of enterprise mobility: Case study insights'. *Information Knowledge Systems Management*, 7, pp.227–241.

Shah, R., Goldstein, S.M. & Ward, P.T. 2002. 'Aligning supply chain management characteristics and interorganizational information system types: An exploratory study'. *IEEE Transactions on Engineering Management*, 49(3), pp.282–292.

Sheng, H., Nah, F.F.-H. & Siau, K. 2005. 'Strategic implications of mobile technology: A case study using Value-Focused Thinking'. *The Journal of Strategic Information Systems*, 14(3), pp.269–290.

Siau, K. & Shen, Z. 2002. 'Mobile Commerce Applications in Supply Chain Management.'. *Journal of Internet Commerce*, 1(3), p.3.

Simatupang, T.M., Sandroto, I.V. & Lubis, S.B.H. 2004. 'Supply chain coordination in a fashion firm'. *Supply Chain Management: An International Journal*, 9(3), pp.256–268.

Soroor, J., Tarokh, M.J. & Shemshadi, A. 2009. 'Initiating a state of the art system for real-time supply chain coordination'. *European Journal of Operational Research*, 196(2), pp.635–650.

Srinivasan, M. & Dey, A. 2014. 'Linking ERP and e-Business to a Framework of an Integrated e-Supply Chain'. In F. J. Martínez-López, ed. *Handbook of Strategic e-Business Management*. Progress in IS. Springer Berlin Heidelberg, pp. 281–305.

Stefan, G. & Kerins, J. 2014. 'Mobile technology-enhanced asset maintenance in an SME'. *Journal of*

Quality in Maintenance Engineering, 20(2), pp.163–181.

Szymczak, M. 2013. 'Using Smartphones in Supply Chains'. *Management*, 17(2), pp.218–231.

Thomas, D. & Griffin, P. 1996. 'Coordinated supply chain management'. *European journal of operational research*, 94(1), pp.1–15.

Tomislav, C., Ljubica, P. & Mislav, Š. 2014. 'Mobile technologies and supply chain management - Lessons for the hospitality industry'. *Tourism and Hospitality Management*, 20(2), pp.207–219.

Tranfield, D., Denyer, D. & Smart, P. 2003. 'Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review'. *British Journal of Management*, 14(3), pp.207–222.

Webster, J. & Watson, R.T. 2002. 'Analyzing the past to prepare the future'. *MIS Quarterly*, 26(2), pp.xiii–xxiii.

Yuan, Q., Xiaokang, Z. & Qiong, Z. 2008. 'Key Technology and System Design in Mobile Supply Chain Management'. *2008 International Symposium on Electronic Commerce and Security*, pp.258–262.