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KNOWLEDGE MANAGEMENT PRACTICES IN CLIENT-SUPPLIER INTER-FIRM RELATIONSHIPS WITHIN SUPPLY CHAINS

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Abstract

In the current knowledge-based and digitalization era, knowledge, which is a critical resource for companies, needs to be managed properly not only in single firms but also across inter-firm relationships and supply chains (SCs) because business competition, rather than among individual firms, is increasingly tends to involve entire SCs. Also, considering the current sustainability challenges, it is becoming vital to coordinate and co-manage company resources, activities, and innovative efforts well beyond the single organization. So, business managers must be aware of the knowledge management (KM) practices that can be effectively adopted and facilitate the assimilation of these practices to promote competitiveness. Standard definitions and classifications with a comprehensive list of important KM practices can be of great help, but the current studies are very limited and fragmented. Also, in line with this, the intensity of use of the KM practices which are adopted by firms, at intra or inter-firm level, is not well addressed by the previous empirical studies.

To fill these gaps, this study primarily contributes to explore the literature and examine the state-of-the art of research on KM practices and identify the most important concepts, definitions, and taxonomies that can be relevant especially for inter-firm relationships in SCs. This is done by using a systematic literature review, based on a combination of a quantitative and a qualitative approach. The descriptive analysis showed the trend and focus of papers in the KM-SC field. Also, through a content analysis, the study discusses a possible systematization of the key KM practices based on the definitions and classifications drawn from the literature. Then, after the inclusion of feedback from KM experts, a first attempt is made to provide a consistent definition of KM practices in business and then to categorize them by introducing a new triple-category classification that considers all the different typologies that should be included. A taxonomy of KM practices which shows a comprehensive list and definitions along with a characterization of each practice, both in general terms and specifically for its application to inter-firm relationship in SCs, is developed. In doing so, the study contributed to the current KM research by making a step towards a systematic conceptualization of KM practices with a special focus on SCs, and by highlighting the gaps that may need to be filled in the future research. In practical terms, the study proposes a structured and synoptic reference, useful for companies and managerial education.

The second goal of the thesis is to investigate which KM practices are adopted, and to measure their intensity of use both at firm and inter-firm level (specifically with their suppliers and customers) to make useful comparisons between internal and external inter-firm KM capabilities. A survey based on a structured questionnaire on a sample of European manufacturing firms is used. The study confirms that the examined practices are known and, to some extent, adopted by the sample firms but with a very different intensity. It was also found that a lower use of KM practices regards the inter-firm level. Also, firms use less intensely those practices which are called “elective” in accordance with the KM literature. The results of a correlation analysis depict that the more intensely the practices are used internally, the more likely the firms will intensely employ them with suppliers and customers. In conclusion, the results of the empirical study help to update the information about the KM practices included in the previously defined taxonomy, by adding data about the degree of adoption and use of each practice. Here, the relative importance of each KM practice is significant both for research and practice.

In short, with this study, the key contribution is the effort to define and newly categorize the KM practices, empirically evaluate their intensity of use, and characterise their potential importance for effective inter-firm relationship in SCs compared to the classic intra-organizational environment which has, so far, guided the KM research for the most. All this is important for both researchers and practitioners, can provide inspiration for future research on the one hand, and can support practical efforts to introduce and develop KM programs in companies on the other hand.

Sommario

Nell'attuale era della conoscenza e della digitalizzazione, la conoscenza, che è una risorsa fondamentale per le aziende, deve essere gestita in modo appropriato non solo all'interno di ciascuna impresa ma anche con riferimento alle relazioni inter-impresa e attraverso le catene di fornitura (Supply chain - SC). In effetti la competizione, piuttosto che singole imprese, riguarda sempre più le intere supply chain. Inoltre, considerando le crescenti di sostenibilità sfide nelle nostre economie e società, sta diventando fondamentale coordinare e gestire in modo condiviso le risorse, le attività e gli sforzi innovativi ben oltre i confini della singola organizzazione. Pertanto, è importante che i manager siano consapevoli delle pratiche di gestione della conoscenza (Knowledge management - KM) che possono essere utilmente adottate e di come facilitarne l'adozione per favorire la competitività delle proprie aziende. A questo scopo, disporre di definizioni e classificazioni appropriate, e di un repertorio standard delle pratiche di KM, può essere di grande aiuto e tuttavia a questo riguardo gli studi attuali sono ancora limitati e frammentati. Inoltre, il grado di utilizzo delle pratiche di KM nelle imprese, sia a livello intraaziendale che interaziendale, non è ancora stato sufficientemente analizzato e c'è necessità di ulteriori studi empirici.

Per colmare queste lacune, nella tesi è stata innanzitutto esaminata la letteratura attuale e in particolare lo stato dell'arte della ricerca sulle pratiche di KM per identificare i concetti, le definizioni e le tassonomie più rilevanti soprattutto con riferimento alle relazioni interaziendali e nelle supply chain. è stata effettuata una revisione sistematica della letteratura, basata sulla combinazione di un approccio quantitativo e uno qualitativo che ha permesso di analizzare sia il trend corrente della ricerca sia i principali oggetti di studio dei lavori presentati sul tema del KM in special modo nelle supply chain. Inoltre, l'analisi del contenuto di tali lavori ha permesso una sistematizzazione delle principali pratiche di KM e delle loro definizioni e classificazioni così come sono state proposte nella letteratura. Sulla base di questa analisi bibliografica e, inoltre, grazie ai feedback ottenuti da colloqui con esperti di KM, nella tesi viene proposta una definizione delle pratiche di KM nel business che dovrebbe permettere una loro migliore e più coerente di categorizzazione. Viene quindi illustrata una nuova classificazione a "tripla categoria" che permette di elencare le diverse tipologie di pratiche di KM che hanno sostanziale rilevanza nel business, fornendone una definizione e categorizzazione adeguata, sia in termini generali sia, specificamente, per la loro possibile applicazione alle relazioni interimpresa in special modo nelle supply chain. Questo primo risultato della ricerca consente di fare un ulteriore passo verso una concettualizzazione sistematica delle pratiche di KM offrendo spunti per la ricerca futura e, in termini pratici, di offrire un riferimento strutturato e sinottico, utile per la direzione delle imprese che per la formazione manageriale.

Il secondo obiettivo della tesi è indagare, tramite un questionario strutturato su un campione di aziende manifatturiere europee, su quali pratiche di KM siano adottate e misurarne il loro grado di utilizzo, sia a livello aziendale che interaziendale (in particolare con fornitori e clienti) il che ha consentito anche di effettuare utili confronti tra le capacità di KM intra- e inter-aziendale. Lo studio conferma che le pratiche esaminate sono note e, in una certa misura, adottate dalle imprese campione ma utilizzate con intensità molto diversa. È stato inoltre riscontrato un minor ricorso alle pratiche di KM nel contesto interaziendale. Inoltre, le imprese utilizzano meno intensamente quelle pratiche che possono essere definite "elettive" secondo la letteratura del KM. I risultati di un'analisi di correlazione mostrano poi che più intensamente le pratiche vengono utilizzate internamente, più è probabile che le aziende le impieghino anche con fornitori e clienti. In conclusione, i risultati di questa analisi empirica contribuiscono ad aggiungere ulteriori informazioni circa le pratiche di KM incluse nella tassonomia precedentemente proposta, con riferimento al grado di adozione e utilizzo di ciascuna pratica. L'importanza relativa di ciascuna pratica è un elemento importante sia per la ricerca che per la pratica.

In definitiva, il contributo fondamentale di questo studio è rappresentato dallo sforzo di definire e categorizzare in modo originale le pratiche di KM, valutarne empiricamente il grado di utilizzo, e caratterizzarne la potenziale importanza ai fini delle relazioni interimpresa nelle supply chain rispetto al classico ambiente intra-organizzativo che ha finora guidato la ricerca nel KM. Tutto ciò è importante sia per i ricercatori che per i manager d'azienda, e da un lato può fornire ispirazione per la ricerca futura, dall'altro può aiutare le iniziative volte a introdurre e sviluppare programmi di KM nelle aziende.

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Acronyms

AI = Artificial intelligence

BBS = Bulletin board systems

CoPs = Community of practices

CRM = Customer relationship management

CV = Coefficient of variation

DoS = Degree of spread

ERP = Enterprise resource planning

ESN = Enterprise social network

IoD = Index of differentiation

IoU = Intensity of use

IoUI = Intensity of use index

KBV = Knowledge based view

KM = Knowledge management

RQ = Research question

SC = Supply chain

SD = Standard deviation

SKOS = Simple knowledge organization system

SLR = Systematic literature review

SRM = Supplier relationship management

1. Introduction

This chapter presents an overview of the thesis, with a general explanation of the background, motivation, objectives, and methods of the research that was conducted during the PhD project. Based on a preliminary analysis of the state-of-the-art of the studies of knowledge management applied to inter-firm relationships in supply chain, it was first possible to formulate the general objectives, plans and methods, as they are outlined in this chapter.

The detailed research questions were further developed after a systematic literature review that was conducted in the first part of the project. This made it possible to identify the gaps in the current literature, refine the research questions, and adjust the methods of the empirical analysis that was later conducted in a sample of companies. These points will be described in detail in the next chapters.

1.1 Motivation of the research

In the last decades, there is a recognized importance of interfirm relationships and their proper management, especially between client and supplier in supply chain (Albino et al., 1998; Attia & Essam Eldin, 2018; Butt et al., 2021; Cricelli & Grimaldi, 2010). It can therefore be argued that, in many sectors, the competition is not simply between individual firms, but tends to involve entire supply chains (SCs) (Attia, 2015; S. Li et al., 2006; Pinto, 2020; Shakerian et al., 2016; Zimon et al., 2019), while firms have an interest in exploiting fruitful collaborations along their supply chain. This importance of inter-firm relationships along SCs has long been underlined (Albino et al., 1998; Cricelli & Grimaldi, 2010), but it is also becoming more and more evident in contingent situations (e.g. in the COVID-19 pandemics (Gregurec et al., 2021; Kumar et al., 2020), even though this study was planned before the COVID time and the goal was not explicitly that of investigating this issue) or due to the long-term trends of the economy (namely; the importance of "sustainable production"). For example, it is necessary that companies and managers reach a high level of maturity in their SC practices to reduce risks of disruptions in case of emergencies (Tubis & Werbińska-Wojciechowska, 2021). Also, today companies must improve their practices with higher awareness of sustainability issues. To survive in global markets where the demand for green and sustainable production is increasing, the effectiveness of interfirm relationships in SC must grow (Stevenson & Spring, 2009; K. Q. Wang et al., 2017).

Therefore, it is often argued that managers should focus not only on internal activities, but also on how the different capabilities, resources, and processes of all the firms in an inter-firm relationship within the SC can be profitably integrated and co-ordinated. Therefore, these emerging business challenges make business management more complex, and new competencies become necessary. Managing interfirm relationships in SCs extends beyond classic approaches, based for instance on performance metrics of cost, time, and flexibility of supplies and deliveries, and requires collaboration and exchange of data, information and knowledge across all companies in SCs, to achieve and maintain competitive advantage and for ensuring the performances that are required, especially under a sustainability perspective (Zimon et al., 2019).

To face these complex challenges, there is increasing awareness, notably in the current knowledge-based and digitalization era (Schniederjans et al., 2020), that knowledge is a strategic resource not only for individual firms (Bolisani & Bratianu, 2018; Bratianu & Bolisani, 2015; Ichijo, 2007; Jafari et al., 2007) but also in supply chains (Attia & Salama, 2018; Hult et al., 2006). Basically, the literature linked with the Knowledge based view (KBV) theory considered knowledge as the most significant resource since the last decade of the 20th century (R. M. Grant, 1996). Thus, it needs to be managed properly and be given prior attention, to enhance a firm's performance (Schoenherr et al., 2014), its capability to introduce innovations (Mardani et al., 2018), and to face changing conditions. In this case, though the issue of how companies should plan their knowledge management (KM) activities has long been a debated issue (Bolisani et al., 2017), as the above mentioned and other related literatures showed, recognition of KM as a strategic element of today's competitiveness is increasing.

When we say managing knowledge or knowledge management here, there are different perspectives as for how to define it. Among the many, let us see some relevant definitions, not actually to propose a long discussion regarding the different definitions of KM but to see the general link to the aims of this research. The one provided by Swan et al. (Swan et al., 1999) defines KM as ''a process or practices for creating, acquiring, capturing, sharing, and using knowledge, wherever it resides, to improve learning and performance in companies''. The second author (Bounfour, 2002) describes KM as a systematic way of creating, sharing and leveraging knowledge within and around organizations. In these two definitions, it can be noticed that the first supports regarding the KM practices and processes aspect and the second one strengthens the operationalization of the concept in inter-organizational settings. Also, another author (Edwards, 2015) conceptualised KM as managing organizational knowledge

considering five important aspects: knowledge content, process, people, technology, structure and strategy. From the KM definitions and related basic concepts provided by these authors and other famous authors on the area (Nonaka & Lewin, 1994; Nonaka & Takeuchi, 1995; Wiig, 1993), it can be underlined that all these generally stress the importance of KM "in practical terms" – which means that it is important to study its practice. Furthermore, it can be seen that the definitions of KM generally emphasize that it is a mix of different processes, methods, techniques, tools and even practices, so it is important to speak of "practices" rather than "practice". As companies in SC interfirm relations are strictly interconnected to one another, techniques and technologies to manage knowledge become integrated with SC systems to monitor operational and environmental performances (Schoenherr et al., 2014; Wernick, 2002) as well as to produce innovations that are economically fruitful and environmentally respectful. Thus, business managers must learn how to effectively manage not only their own knowledge but also the knowledge of all those that are involved in their business by adopting the important KM practices.

The application of KM can be seen at either an intra-organizational or an inter-organizational level; where the intra-organizational KM is the original and still central definition in the KM literature, there is a growing number of authors that also underline the importance of inter-firm (or inter-organizational) KM: the application of KM to manage the relationships between external partners (i.e., suppliers, customers, service providers, etc) (Agostini et al., 2020; Attia, 2015; Tesavrita et al., 2017; Van Wijk et al., 2008). Different business issues may affect each distinct company in a SC, but it is important to address solutions from a general rather than an individual point of view, and this is increasingly important for a sustainable production and growth, where the effort of the single individual or isolated organization, although important, is insufficient. Therefore, KM between different companies is even more important than that of the company itself. In this vein, there has been a progressive shift of focus to inter-firm KM which has become increasingly relevant (Agostini et al., 2020; Tesavrita et al., 2017; Van Wijk et al., 2008): knowledge is a critical resource that must be managed properly not only in single companies but also in inter-firm relationships across SCs. In substance, knowledge generated in any part of a SC and flowing through inter-company connections must be managed properly for a successful business of all the companies involved (Cristian Aarón Rodríguez-Enríquez et al., 2015; Thomas et al., 2017). This can imply, for example: adopting proper processes and technologies to acquire and absorb knowledge from suppliers and customers, undertaking effective activities for joint knowledge creation and problem solving with business partners,

using approaches to sharing knowledge among the appropriate SC members with the adequate level of protection, activating mutual learning processes in joint projects for the benefit of all involved partners, etc.

In this study, the main topic of analysis is inter-firm KM and, as clarified above, the SC environment is an elective context to study inter-firm relationships. Increasingly, scholars see the development of "knowledge-based SCs" as an opportunity for companies to achieve better value for customers (Patil & Kant, 2013; Wadhwa & Saxena, 2005) and to promote better use of resources in knowledge-intensive and multi-cultural enterprises (Samuel et al., 2011). Also, as the current challenging business environment (including the impact by the COVID-19 pandemic) clearly shows, companies must take appropriate countermeasures to possible disruptions in operations and logistics. The use of proper KM practices can help to reduce the knowledge gaps that are key in the management of purchases, supplies, and sales, to ensure a traceable and transparent environment. In short, it is vital for current and future managers of SCs to understand how to implement and apply appropriate KM practices, not only in their organizations but also in the relationships with external partners.

Though KM and SC are two important research streams, insufficient works have treated the link between them (Samuel et al., 2011). Actually, important contributions have been published in the last 20 years and there are some studies (Liang Chen et al., 2018; Hult et al., 2004; Marra et al., 2012; Pinto, 2020; Schniederjans et al., 2020) showing that there is a growing interest in applying KM to SCs. The literature on the KM-SC topic (Bhosale & Kant, 2016; Cerchione & Esposito, 2016; Pérez-Salazar et al., 2019) is, however, fragmented, and the research has sometimes taken diverging directions. Moreover, there is still a lack of shared definitions or classifications, especially as regards the notion of KM practice, in general and with reference to inter-firm relationships in SCs. The problem of giving a proper definition of KM practice will be treated later in the thesis. Here, it is just useful to anticipate a few examples of the existing confusion even between basic concepts.

For instance, there is a confusion between KM practice and KM process, which are popular and, apparently, similar terms in the literature: indeed, KM deals with both practices and processes that are deemed to enable efficient and effective management of knowledge resources (Alavi & Leidner, 2001; Le Chen & Fong, 2015; Garrido-Moreno et al., 2014). Some authors (Azizi et al., 2016; Durst & Evangelista, 2018; Khyzer Bin Dost et al., 2018) simply consider KM practices as the same of generic KM processes (like knowledge creation, sharing, application). The notion (KM process) is important in the KM literature (Edwards, 2015) and

is useful to distinguish between different basic activities of knowledge handling (for example, knowledge creation is different from knowledge transfer), but has little practical usefulness from a managerial viewpoint because it does not necessarily clarify how to perform each of these activities. In addition, other authors see KM practices as activities aimed at managing the organizational knowledge resources and enhancing knowledge processes of the firm (Andreeva & Kianto, 2012; H. Inkinen et al., 2017; Kianto & Andreeva, 2014), which seems to imply a sort of hierarchical relationship between the two concepts.

In addition, there are authors who consider KM practices as critical success factors or enablers; others simply see KM practices as set of methods, techniques or organizational/ managerial activities related to knowledge resources in some way – this will be discussed in detail later. In short, while the term "KM practice" is often used, there is no consensus about neither a standard definition, nor a classification of possible existing practices. There are a few studies of which KM practices are used by firms (Centobelli et al., 2019; Cerchione & Esposito, 2016; H. Inkinen, 2016; Q. Li & Kang, 2019), and even these limited number of studies sometimes take diverging views and did not address all the possible KM practices in their studies. A unified vision or perspective has not emerged so far. What is mentioned here is the case of both KM in general, and its application to inter-firm relationships (in SCs), although it must be said that the notion of KM practice is rarely treated with an explicit characterization for inter-firm relationships (in SCs).

In general, just a quick analysis of the current studies is sufficient for highlighting that the literature does not yet offer a clear and complete picture of what a KM practice is and what practices are or can be specifically used, not only in inter-firm relationships but also internally in the single company. In addition, the level or intensity of use of KM practices by firms has not been investigated sufficiently. There are few empirical studies that assess the applicability of KM practices in companies and in SCs (Centobelli et al., 2019; Cerchione & Esposito, 2016).

In short, what reported here shows that KM practices in SC inter-firm relationships can represent an important object of research in the KM literature which is still insufficient in this regard. A study that clarifies definitions and classifications of KM practices, and provides empirical data about how these are adopted either in the intra-firm and inter-firm environment can therefore contribute to the current research. In addition, from the point of view of a practitioner, this study finds a motivation in the awareness that there are many different KM practices, and that having a "comprehensive and clear list" can help managers to understand where and how to apply them. Especially, showing the importance of KM practices for SC

inter-firm relationships in a comprehensive manner is also important because this extends the notion of KM to inter-firm collaborative environments which, as mentioned, is a real challenge of the current economy.

1.2 Objective of the study

This research essentially focuses on the study of knowledge management practices in inter-firm relationships, with the goal to investigate how KM practices are applied not only internally but can also extend beyond the company's boundaries and are adopted to facilitate inter-firm relationships. It mainly focused on client-supplier relationships in SCs as an important example of inter-firm relationships. The detailed aims, based on a systematic literature review (that will be described in the next chapters) and the specific gaps in the current research, can be summarized in the following research questions which will be further explained later: RQ1: What is or can be a knowledge management practice (i.e., what definition can be proposed)?, RQ2: Which KM practices are mainly used or proposed for application in companies (internally) and inter-firm relationships (in SCs) and how can be these practices categorized in a consistent way?, and RQ3: To what extent (i.e., level of adoption and intensity of use) these KM practices are exercised by firms?

So, the first basic objective that has been defined in relation to RQ1 and RQ2 was to systematise the different definitions and classifications of KM practices available in the literature, and single out and categorize the KM practices that can be used by firms to enhance KM implementation in inter-firm relationships. With this objective of the study, an attempt was made to provide a consistent definition of KM practice and, secondly, to introduce a new comprehensive classification of KM practices that considers all the different typologies that should be included. The second objective of this study, which is basically related to RQ3, is an empirical investigation of the level of adoption and use of KM practices both at the company and inter-firm level (namely, customer-supplier relationships in SCs). In doing so, this study made an important contribution to fill the gaps in the current literature, mentioned slightly in the introduction section but in detail in the next chapter (section 2.5). These objectives are also important for business managers and consultants, to increase their awareness of the KM practices that can be effectively adopted not just in companies but also in inter-firm relationships, and to facilitate the assimilation of these practices to improve competitiveness of firms and entire SCs. This can also be useful for the design and implementation of KM courses devoted to current and future business managers.

1.3 Methodology and Organization of the study

1.3.1 Research method

To address the above-mentioned research objectives, in general, this study was done by means of an extensive systematic literature review and experts' opinion for answering RQ1 and RQ2, and survey for answering RQ3. The methodology has been organised into five phases (figure 1) as follows:

I) Systematic literature review (Desk analysis):

Primarily, based on an input found from the preliminary analysis (presented in section 1.1), an in-depth systematic survey of the recent scientific literature using a combination of a quantitative and a qualitative approach is conducted. Based on a selection of the literature, the state-of-the art of the current research on KM for SCs was examined, with the purpose to identify the most important concepts, definitions, and taxonomies that can be relevant for interfirm relationships in SCs. Especially, notions and classifications of KM practices whose adoption is proposed in inter-firm relationships within the SCs were examined and systematized, with the goal to introduce a new consistent categorization. Furthermore, the development of an initial list of KM practices was one of the outcomes of this phase. This analysis, along with a further review of additional important studies later to include firm level perspectives and notions of KM practices using firm-focused documents, contributed to address RQ1 and RQ2.

II) Feedback from experts and practitioners:

In this phase, the proposed initial definition, and draft lists of KM practices along with their classification have been evaluated by KM experts (consultant, managers, and academicians - which will be discussed in detail later in section 3.2 together with the participants for the survey questionnaire pilot testing). Based on this feedback, the revised version of the initially proposed definition, and the refined and categorized lists of KM practices were developed. This analysis also contributed to address RQ1 and RQ2 by strengthening the analysis of phase one and used as an input to design the survey.

III) Development of questionnaire and taxonomic scheme:

Based on the outputs from the review of the existing studies and the feedback from KM experts, a comprehensive list of KM practices with a triple-category classification is provided, and a characterization of each KM practice is defined both in general terms and specifically for its

potential application to the inter-firm relationships in SCs (taxonomic scheme). Then, a draft structured questionnaire is designed focused to investigate which KM practices are adopted to manage knowledge both at firm and inter-firm levels and, with a scale, to measure the level of adoption and intensity of use of each practice.

IV) Pilot testing of the questionnaire:

The draft version of the questionnaire has been tested by some KM experts and company managers to check if the questions are understandable (including clarity, redundancy, and relevance related issues) and manageable for a manager in a manufacturing or utility company. Then, based on the feedback given, the final version of the questionnaire is developed.

V) Field analysis (survey):

An online survey questionnaire with the google form tool was used to collect data through direct contact via email and other ways of communication tools in a sample of medium and large European companies. A main source of contacts was LinkedIn, and especially KM professional group LinkedIn pages. Other contacts were added by using my personal network or that of my supervisors. Key informants (e.g., executives or top- level directors, KM officers, etc.), were asked to respond to a structured questionnaire focused on which KM practices are adopted and on their level of use by the firms both at firm and inter-firm levels (with their suppliers and customers) to make useful comparisons between internal and external KM capabilities. Descriptive statistical analysis was carried out with the purpose to identify the most exercised practices and their intensity of use, and other secondary aspects. Details about the survey approach, context of investigation and sampling, are presented later in the empirical study part of this thesis report (chapter four).

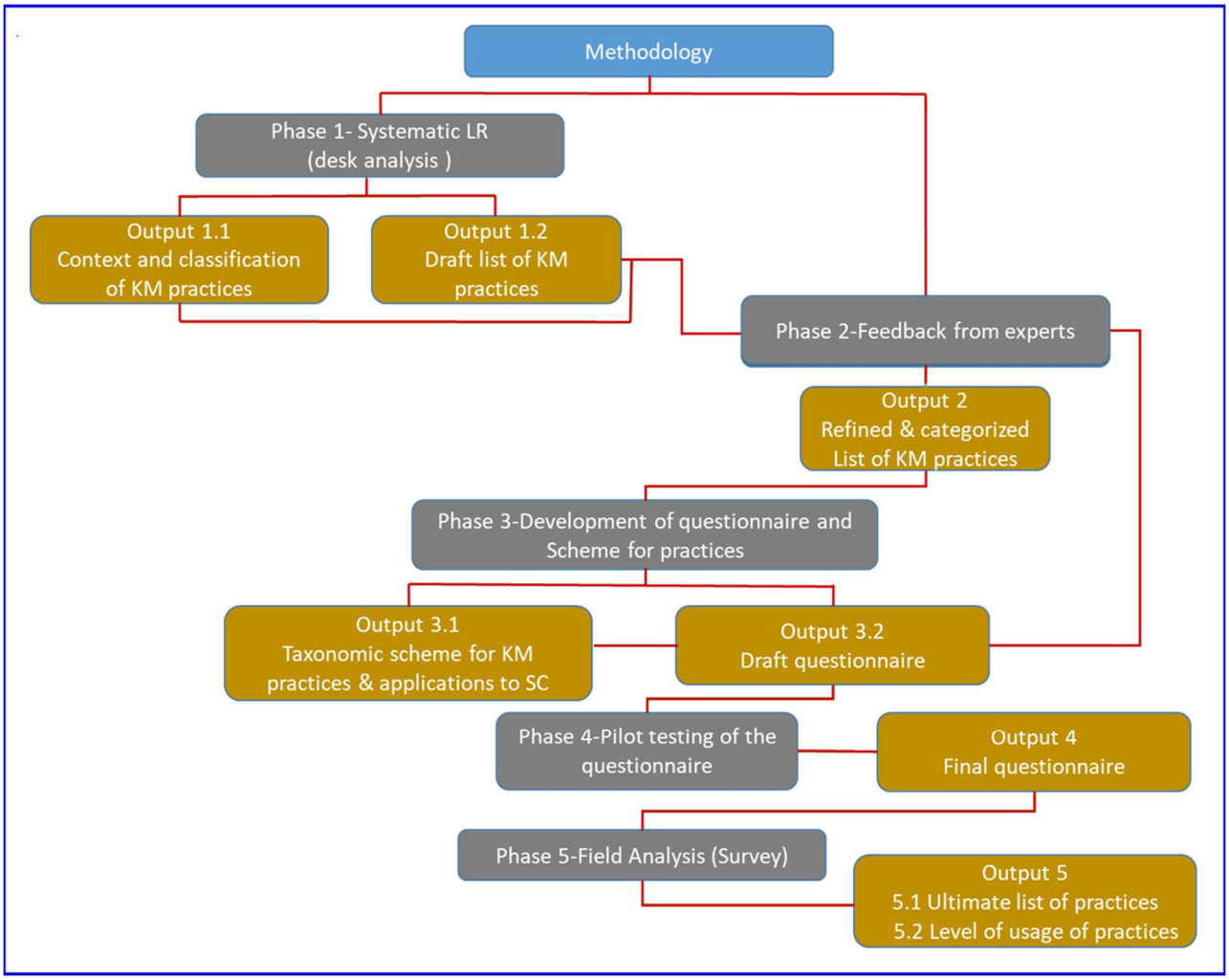


Figure 1. Flow chart of the research methodology

1.3.2 Organization of the study

The next chapters of the study are structured as follows. Chapter 2 describes the systematic literature review. This chapter primarily summarizes the quantitative analysis of the selected papers, by means of a trend analysis and a content analysis. Then, it illustrates the qualitative analysis of the main issues of KM in SCs as they emerge from the selected papers and discusses the main classifications and definitions of KM practices applied to interfirm relationships and SCs as they are proposed. Also, based on the gaps emerged from the literature review, research questions formulated for a further investigation are presented in this chapter. Chapter 3 advances the proposal of a definition and new systematic classification of KM practices into primary categories. Chapter four is about the Empirical part of the study which explains the survey investigation, the context of the research and the survey approach used. Chapter five details the analysis and results of the study. The main findings drawn from the descriptive statistical analysis with respect to the level of adoption of the proposed practices and their

intensity of use among the sample investigated firms are the main parts of this chapter. Moreover, the correlation analyses that are carried out to know the relationships between the use of practices internally and at inter-firm level are included in the subsequent parts of this chapter. The final chapter summarizes conclusions drawn, the main usefulness of the study, the implications for research and practice, and the limitation and future directions of the research.

2. Systematic literature review

2.1 Review methodology

A systematic literature review (SLR) is used for this study as it is an overview of primary studies using explicit and reproducible methods (Greenhalgh, 1997) following a rigorous search procedure. The five steps followed for this kind of study (Martins et al., 2019; Xavier et al., 2017) includes: Formulation of the research question, Studies location (searching studies by keywords definition and database selection), Selection and evaluation of studies using inclusion/exclusion criteria, Analysis and summary of the selected articles and results, and Reporting and use of results for further action. This approach is particularly useful for analysing a field or a topic where numerous studies have already been published but the overall picture is still fragmented and variegated, and there is the need to detect the key points of the actual and potential research. In coherence with these typical SLR steps, the adopted SLR strategy is described below.

I) Formulation of research questions for the SLR

Based on the critical points emerging from a preliminary analysis of the literature as described earlier in sections 1.1, the following three research questions (RQ) are formulated for conducting the SLR.

RQ1: How does the trend of KM for SC look and which topics are most importantly covered (or not covered)?

RQ2: What are the different notions, definitions, and classifications of "KM practice" in the literature?

RQ3: Based on these studies, what KM practices are mainly used or proposed for application to SCs?

II) Studies location (Keywords definition, construction of search strings, and choice of databases)

Since the general focus of the study is to see KM in inter-firm relationships along SCs, the articles considered for this study must focus on both KM and SC topics. Accordingly, the selected key words include: "knowledge management", "knowledge creation", "knowledge acquisition", "knowledge storage", "knowledge sharing", "knowledge transfer", "knowledge application", and "Knowledge protection", which are typical key terms related to KM and KM

processes (Edwards, 2015; Holsapple & Singh, 2003; Jean et al., 2014; Q. Li & Kang, 2019). These keywords were used in combination with "supply chain" as shown in the constructed search strings in table 1. Both Web of Science and SCOPUS are used as they are popular and authoritative citational databases and collect a great number of publication sources of all disciplines.

III) Selection and evaluation of studies using inclusion/exclusion criteria

The following criteria are used to further refine and select the initially retrieved papers:

- Focus of the paper on some kind of practical application of KM, KM adoption and development factors, KM technologies, methods and tools, and KM strategies that can be applicable in SCs.
- Articles in peer-reviewed journals indexed in the Scientific Citation Index or Social Sciences Citation Index (Web of Science database), and the Scimago index (Scopus).
- Articles in the business and economics, management, operations research and management sciences, industrial engineering, information system, and related research fields.
- Articles written in English language.
- Articles published from January 2000 to December 2019 (to see the research trend in the last two decades)

According to the above-mentioned search strategy and inclusion/exclusion criteria, and after the duplicates have been removed, a total of 831 papers were undergone a further evaluation process (i.e.: article title reading, abstract reading, and full paper reading), and finally, 65 papers are considered for further descriptive and content analysis. The detail procedures and results are shown in table 1.

Table 1. Paper search and evaluation process and results

Search and evaluation Processes	**Results**	**Remarks**
SCOPUS search (after refined by *time span, language, document type and research area)*	634	Search string: *(TITLE-ABS-KEY ("knowledge management" OR "knowledge creation" OR "knowledge acquisition" OR "knowledge storage" OR "knowledge sharing" OR "knowledge transfer" OR "knowledge application" OR "knowledge protection") AND TITLE-ABS-KEY ("supply chain"))*
Web of Science search (after refined by *time span, language, document type and research area)*	436	Search string: *TOPIC: ("knowledge management" OR "knowledge creation" OR "knowledge acquisition" OR "knowledge storage" OR "knowledge sharing" OR "knowledge transfer" OR "knowledge application" OR "knowledge protection") AND TOPIC: ("supply chain")*
Total papers found	**1070**	
Duplicates	239	Using EndNote software "find duplicates" function (164) and manually (75) papers have been identified and excluded
Papers after duplicates	**831**	
Excluded papers by Article title and/or purpose reading	357	Title and/or declared purpose of a paper which is not related to the research objective is excluded
Papers for full Abstract reading	**474**	
Excluded papers by Abstract reading	225	A paper whose abstract does not focus on both KM and SC is excluded
Papers for full content reading	**249**	
Excluded papers by full content reading	186	Papers that do not show clearly either KM related practices or factors for KM in SC are excluded
Papers after full reading	63	
Extra papers added	2	Added from reference lists
Total papers considered for analysis	**65**	

IV) Analysis and synthesis of the selected articles and findings

The analysis and synthesis of the selected documents was the next step in which descriptive and content analyses were conducted. In the descriptive analysis, the articles were classified according to the following six perspectives, to give a summary view of the investigated articles and the research field.

- By publication year (to see the trend of the research field)
- By research approaches and research methods used by the studies
- By unit of analysis (firm level, SC level or network level)
- By KM adoption or development factors (enablers, barriers or not covered at all)
- By authors' Keywords (to see importantly covered topics)
- By the types of KM processes covered in the studies

In the content analysis, papers were reviewed and studied thoroughly, and important points regarding KM practices and associated issues were extracted and analysed, with the main goal to single out the application context, definition, and classification of KM-related practices in SCs.

V) Reporting and use of review results for further action

This final step is concerned on summarising and reporting, make a further discussion, and establish conclusions on the research findings. In this step, the gaps in the literature, further research directions and the implications are also presented. Moreover, in our case, formulation of research questions, based on the literature gaps, for a further theoretical and empirical analysis is included in this step. The details for this step are presented next to the analysis and synthesis part of the SLR in the following sections of the report.

2.2 Descriptive analysis and the results

2.2.1 Analysis of papers by publication year and the trend

From the classification of the selected papers by publication year, figure 2 shows that, for the past 20 years, there is a general increasing trend of research on KM in SC. Specifically, in the last decade, a fast increment appears: only 18.5% of the papers were written from 2000 to 2010, and the remaining 81.5% were published after 2010, which is a triple number. Thus, the trend displays a significant growth and reveals that there is increasing interest in this field. It also shows that this area of research is promising, and there may still be a lot to discover.

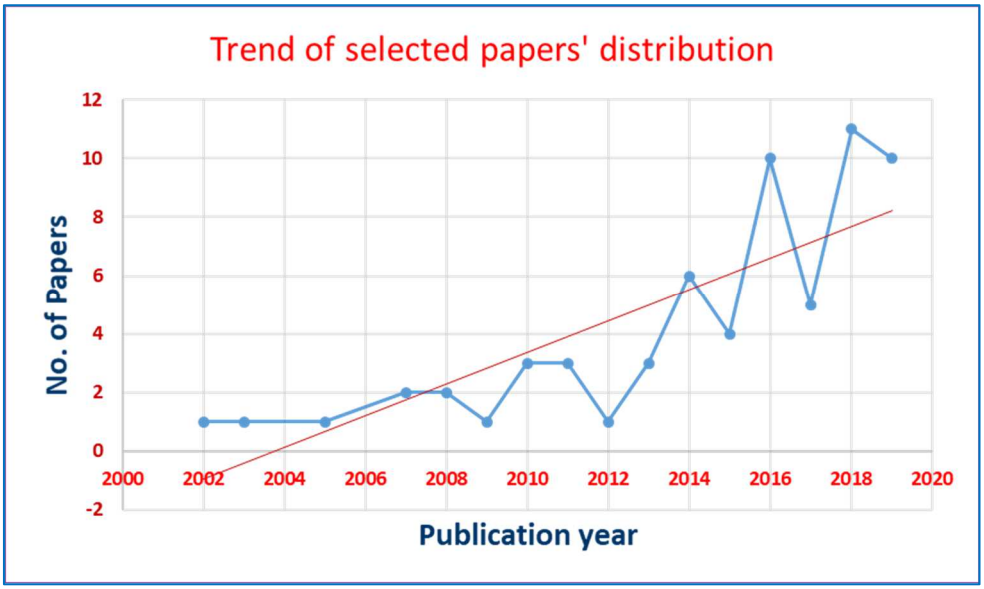


Figure 2. Distribution of papers by publication year

2.2.2 Analysis of papers by research approach and method

Concerning the general research approaches followed, papers are categorized in two ways. Primarily, they are categorized as empirical, theoretical/conceptual, mixed and review papers (table 2, research approach-I). Qualitative, quantitative, mixed and review approach is the second way of classification (table 2, research approach-II). From these two classifications, empirical (66.2%) from the first classification, and quantitative (43.1%) followed by qualitative (36.9%) from the second classification are the frequently used research approaches. In general, theoretical studies are found few compared to the empirical studies. For this finding, among other reasons that needs a further investigation, one can be due to the case that the majority of the selected papers, based on our inclusion criteria, discussed one or more kinds of KM practices which is mostly expected that such research issues are addressed following an empirical research approach.

Table 2. Classification of papers by research approach

Research approach-I	**Frequency**	**%**	**Research approach-II**	**Frequency**	**%**
Empirical	43	66.2	Qualitative	24	36.9
Theoretical/conceptual	6	9.2	Quantitative	28	43.1
Mixed	12	18.5	Mixed	9	13.8
Review	4	6.2	Review	4	6.2

Another classification of the papers was by the research methods followed in the studies and thus, the result in Table 3 shows that survey (46%) and case study (35.4%) are commonly used research methods. However, there is a limitation in the use of conceptual models, mathematical models, and action research methods in the area. Furthermore, for the empirical studies, data collection tools mostly used include questionnaire for the survey method, and Interview and focus group discussion (experts' opinion) for the case study method. This result supports the findings of the study by Perez-Salazar et al (Pérez-Salazar et al., 2019). Also, the analysis identifies that Structural equation modelling, Factor analysis, Fuzzy and AHP are frequently used data analysis methods/tools.

Table 3. Classification of papers by research method

Research method	Frequency	%
Survey	30	46.2
Case study	23	35.4
Conceptual model	3	4.6
Review	4	6.2
Mathematical model	1	1.5
Action Research	1	1.5
Other	3	4.6

2.2.3 Classification of papers by unit of analysis

Papers were also classified by the unit of analysis of studies, i.e.: firm level, SC level, or supply network level. With this respect, most of the papers (54%) adopt a firm-level unit of analysis (Table 4). In fact, the analysis of KM issues at a SC or supply network level is clearly more difficult, as it is not easy to detect and examine the KM practices in a SC across all the possible involved firms. Thus, this can be seen to be a point of weakness of many studies. However, it may also show that KM practices in a SC may be adopted by trading partners (customers or suppliers) under the support or pressure of a key company in the SC (for example, a large manufacturer with its suppliers or customers). This is important for researchers in a way that by analysing the practices of these key companies, it is often possible to learn the KM practices that are used in SC. It is also vital for practitioners, namely, the initiative taken by the predominant firm can be essential for the application of KM practices in the inter-firm relationships (in the SC).

Table 4. Classification of selected papers by ‘‘unit of analysis’’

Unit of analysis	Frequency	%
Firm level	35	53.9
SC level	24	36.9
Network level	6	9.2

2.2.4 Classification of papers by KM factors

This analysis was conducted to investigate how much the issue of KM adoption or development factors (enablers, critical success factors or barriers), which are essential to the successful implementation of a KM program, are covered by the KM-SC studies. In this case, about 65% of the studies (figure 3) considered the issue of KM factors, in general, in their discussion and the rest of the studies did not consider it at all. From the preliminary literature review, this study had initially found that there was a limited study on factors (both enablers and barriers) influencing KM adoption and development in SCs (Cerchione & Esposito, 2016). Meanwhile, this systematic literature review indicated that there are some studies that discussed on enablers and success factors (52%), but very few papers on barriers (only 8 papers or 12%). This result supports the findings of other studies (Q. Li & Kang, 2019; Zerbino et al., 2018). Thus, in the case of the present limited implementation status of KM in SCs, studies on factors hindering KM activities in SCs are necessary, and more attention must be given to this research topic in order to facilitate the successful adoption and development of KM practices in SCs and benefit companies from a collaborative inter-firm learning.

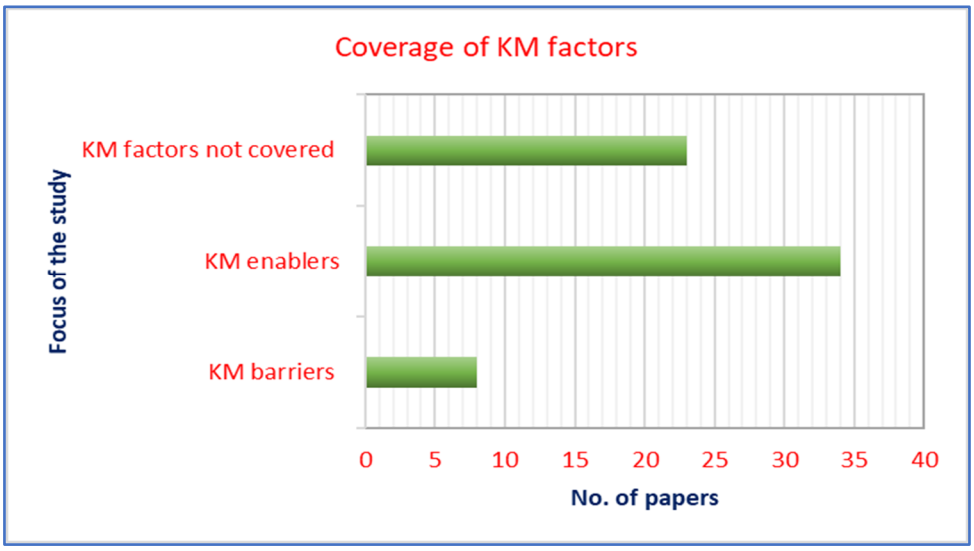


Figure 3. Classification of papers by coverage of KM factors in SCs

2.2.5 Analysis of papers by authors' keywords

Authors' keywords used in the selected papers were collected and analysed to investigate the most importantly covered and uncovered topics in KM-SC research area. From the final selected 65 papers, we found a total of 331 keywords. These keywords were organized by using Excel query commands and analysed using word cloud software, and then, we found the picture shown in figure 4 that can show us the overview of the coverage of some important topics. From the KM field of study perspective, 'Knowledge management' (30), 'Knowledge sharing' (11) and 'Knowledge transfer' (7), whereas from supply chain, 'supply chain management" (14), 'supply chain' (14) and "SC collaboration/ collaborative SC" (7) are keywords frequently occurred. This indicates that these are the most importantly covered topics in the study area. From KM processes perspective, knowledge protection was not found at all, and it implies that the topic is substantially neglected in KM-SC context.

Figure 4. Keyword cloud

2.2.6 Analysis of papers by KM processes

This analysis aimed to identify the main KM processes that are often considered from the "KM in SC" perspective, and to learn which processes are mostly covered/not covered by the studies. To do so, a pre-compiled list of "generic" KM processes was necessary. In the literature, different directories of KM processes have been published (Edwards, 2015; Heisig, 2009). Based especially on authors who focused on KM in SCs (Cerchione & Esposito, 2016; Nikabadi, 2014; Phengchan & Thangpreecharparnich, 2018), six key KM processes can be

considered, i.e.: Knowledge Acquisition, Creation, Storage/Retrieval, Transfer, Sharing, and Application. Also, due to the need for knowledge protection in inter-firm knowledge exchanges (Jean et al., 2014; Q. Li & Kang, 2019) especially relevant in a SC setting due to its multiple touchpoints (Schoenherr et al., 2014), i.e., using sound knowledge safeguard/protection measures to encourage knowledge sharing in one hand and shielding the acquired knowledge from outside dissemination (Norman, 2004) to reduce knowledge leakage in SCs on another hand, additional KM processes must be included in the KM-SC perspective, i.e. "knowledge protection". Based on this list, the selected papers were classified as shown in figure 5.

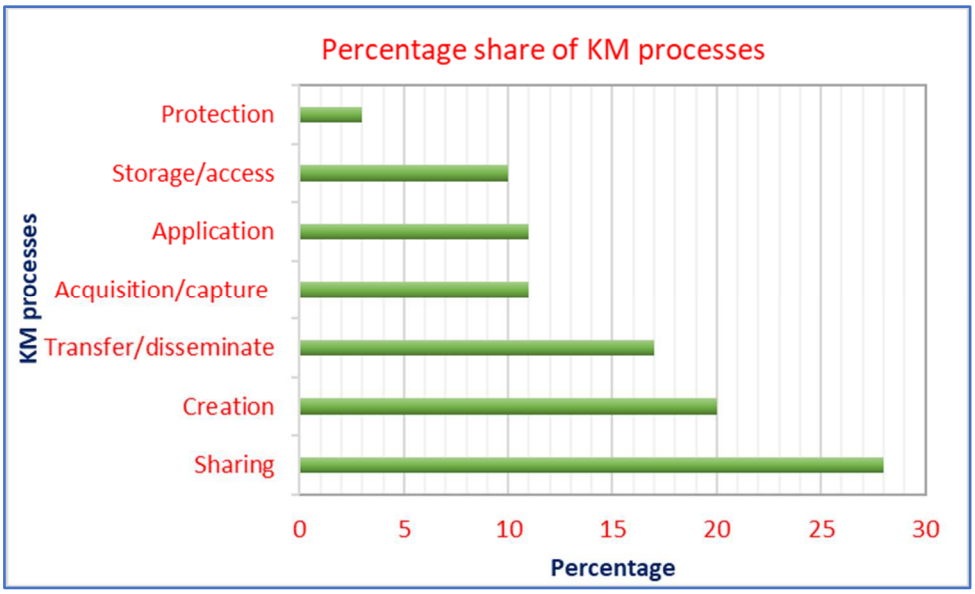


Figure 5. Classification of papers by coverage of KM processes in SCs

As the picture (figure 5) for the coverage of KM processes in SCs shows, ''Knowledge sharing'' (namely, collaborative exchange of knowledge between individuals which boost mutual learning and new interpretations) and ''Knowledge transfer/dissemination'' (i.e.: the process where a "piece" of knowledge is passed from a source to a receiver for using it in its work) together cover around 45% of all KM processes considered in the studies. The prevalence of these distinct but correlated processes signals that how to exchange knowledge effectively in inter-firm relationships within SCs and what methods or tools to adopt for that are still considered key questions.

On the other hand, Knowledge protection (3%) has got very little coverage, which may signal that the risk of "leakages of precious knowledge" in SC inter-firm relationships is not considered critical, or that researchers still must do more research on this topic. Knowledge

acquisition (i.e., how firms can assimilate and integrate different knowledge resources from each SC members) is also not considered as a crucial process.

In summary, the quantitative or descriptive analysis part of the systematic literature, based on the above discussed six perspectives, gave us a summary view of the investigated articles and the KM-SC research field in the last two decades. Accordingly, it can be affirmed that the literature is increasingly putting an emphasis on the application of KM in SCs. Among the main results, the trend analysis by publication year reveals as there is increasing research interest in the KM-SC filed; the analysis of papers by research methods indicates the predominancy of empirical research; most of the studies used a firm level unit of analysis but a limited studies on SC or network level analysis; and though most of the studies considered the KM adoption or development factors, very few papers conducted on KM barriers. Moreover, the analysis of studies both by the authors' keywords and the types of KM processes covered in the studies showed us the importantly covered and uncovered topics in the area. Having this descriptive analysis, in the next section, the study proceeds to have an in-depth analysis of the content of the studies.

2.3 Content analysis and results

2.3.1 KM practices: notions, definitions, and classifications

In this section, after a thorough reading of the selected papers and analysing the important contents, it is highlighted that KM practices are defined and categorized by different authors in a fragmented way, and that an effort of systematization is necessary for several reasons. First, having a list or a sort of "reference catalogue" of KM practices is important for managers and executives, at least when they are aware of their company's needs to implement KM programs, methods, or technologies, or when their company is asked to adopt these practices as a request of their leading business partners (suppliers or customers). In addition, a clear comprehension of KM practices and their characteristics is also important for business education and training: to design KM courses in business – both for internal practice and also to manage inter-firm relationships – a reference definition of KM practice and a consistent classification are also essential. This is greatly important for helping students and future executives to select and apply the proper practice in the different practical situations they will face in their profession.

While, as was shown in the previous section, it can be affirmed that the literature is increasingly putting an emphasis on the application of KM in SCs, a significant limitation is that many different notions and categorizations regarding KM practices are proposed, both at intra- and

inter-firm level. Because of this issue, it was also included, in the analysis, some important papers which have discussed KM practices even not under an inter-firm or SC perspective.

According to some scholars (Andreeva & Kianto, 2012; H. Inkinen, 2016; H. Inkinen et al., 2017; H. T. Inkinen et al., 2015), KM practices are generically defined as a set of organizational and managerial activities intended to achieve organizational goals through efficient and effective management of a firm's knowledge resources. Centobelli et al. (Centobelli et al., 2017) and Cerchione et al. (Cerchione et al., 2015) define KM practices as a group of methods and techniques for supporting KM development. Some authors define KM practices as enablers (Anand et al., 2015) or critical success factors for KM (Lee et al., 2008; Yang et al., 2009). Others (Azizi et al., 2016; Durst & Evangelista, 2018; Khyzer Bin Dost et al., 2018) simply consider KM practices as the same of generic KM processes (like knowledge creation, sharing, application) that can also be applied to the specific case of inter-firm relationship in SCs (Y. Li et al., 2012).

For some authors, IT-based KM activities (Bertoni & Larsson, 2011; H. Inkinen, 2016), and other managerial activities that are not explicitly targeted to KM but can nonetheless be important for handling knowledge resources (Andreeva & Kianto, 2012; Charterina et al., 2018; H. Inkinen, 2016) or can support the introduction and development of KM programs, are not considered as (part of) KM practices. Others (Centobelli et al., 2017, 2019; Cerchione et al., 2015) adopt the term "KM system" which consists of "KM Practices", defined as a set of methods and techniques for supporting KM development, and "KM Tools", namely the specific IT-based systems for KM. In short, the use of IT-based technologies is considered as a separate case from KM practices, even though the use of technologies is generally considered (Edwards, 2015) as integral part of KM activities.

If there is no standard definition of KM practice in the literature, there is not even consensus concerning the different typologies of KM practices (H. Inkinen et al., 2017). For example, some authors (Azizi et al., 2016; Durst & Evangelista, 2018) classified it just like KM processes in to three to five different categories, and others (Centobelli et al., 2019; Cerchione & Esposito, 2017) classified practices in to two groups: KM practices in terms of "organizational" methods, and IT-related KM practices. An attempt to provide a comprehensive classification is made by Inkinen et al. (H. T. Inkinen et al., 2015). They divide KM practices into ten categories, namely: strategic KM, supervisory work, knowledge protection, IT practices, learning mechanisms, organizing work, recruitment, training and development, performance appraisal, and compensation practices (the last four practices, actually, are the same as typical

human resource management practices). This categorization is important because, unlike others, it encompasses many of the core KM aspects (Edwards, 2015) and draws a distinction between KM practices and KM processes, by affirming that these make different contributions to performance management (innovation performance). However, this classification has some limitations. For example, it remains at an overall level, and it may be difficult to apply it in the practice or in the case of business education. Another limitation related to this aspect is that, too many categories are difficult for practitioners to manage. In addition, its application to inter-firm relationships and SCs is not evident. Furthermore, a comprehensive and updated list of single specific practices are not provided under each category.

In general, based on this literature analysis, it can be said that a complete picture or set of KM practices both at intra- and inter-firm level is not yet available. In particular, the examined papers do not often go deeper into the specific application or importance of each KM practice for inter-firm relationships in SCs.

2.3.2 KM practices: Identification of lists of practices

Apart from the analyses of the different notions, definitions, and classifications of KM practices, based on the content analysis of these studies, different KM practices are identified in general and those mainly used or proposed for application to inter-firm relations in SCs are characterised by highlighting their importance. An initial draft list of more than 57 KM-related practices are identified and sent to some KM experts (details in section 3.2) for their evaluation and feedback concerning the relevance to the application in inter-firm relationships in SCs and eliminate substantial replications. These findings are summarised and presented later, along with the newly proposed categorization of KM practices, in the following chapter in section 3.2.

2.4 Summary and comparison to previous literature reviews

In addition to the original collection and analysis of papers, there are other recently conducted literature reviews (Bhosale & Kant, 2016; Cerchione & Esposito, 2016; Pérez-Salazar et al., 2019) that are pertinent to this thesis. As depicted in table 5, these have been selected for highlighting their contributions, showing the limitations, and providing comparisons so that it will give not only an additional input to this study but also represent a note for future literature reviews on the same topics. Compared to these reviews, the one presented here differs primarily because it extends these by adding:

- Authors' keyword analysis, to know the most importantly covered topics in the last 20 years
- Analysis of KM processes analysed in the papers (including Knowledge protection as a KM process which is particularly important in the case of inter-firm SC relationships)
- Classification of papers by "unit of analysis": firm level, SC level and supply network level
- Classification of papers by KM factors (enablers, barriers or not considered at all).

Secondly, this review is "topic-specific" because it focuses on KM-related practices that support and facilitate the management of knowledge resources not only inside firms but also in their relationship with SC partners. In addition, differently from other literature reviews, this study provides insights that are useful for a systematisation of the definition and a classification of KM practices as there was not a common notion of the area.

Table 5. Summary and comparison of three selected literature reviews pertinent to this study

Author	Title	Focus of the review	Findings of the review	Remarks
Bhoshale & Kant (2016)	Metadata analysis of knowledge management in supply chain: investigating the past and predicting the future	To present a comprehensive and useful insight into the KM in the SC research and provide gaps and future research implications	Shows the increase in the interest level of incorporating KM in SC; the statistics prove that research in the field of KM in SC is overwhelmingly empirically oriented and Implementation of KM processes other than sharing & transfer in SC activities are limited.	*Papers published: 2001 – 2014, needs updating *Limited to Scopus database * General review ()
Cerchione and Esposito (2016)	A systematic review of supply chain knowledge management research: State of the art and research opportunities	To identify the state of the art in the literature, highlight research gaps, and define appropriate research questions to be addressed	Identified research issues which are still neglected, particularly gaps on the factors affecting the adoption and development of KM practices, systems to support KM, barriers to the adoption of KM practices and impact of adoption of KM practices on performance	*Papers published: 1960 - 2014, needs an updating *Though many specific gaps are identified, KM practices are not directly covered
Pérez-Salazar, et al (2019)	Processes and measurement of knowledge management in supply chains: an integrative systematic literature review	To build upon previous LRs focused on KM in SCs from an integrative perspective as an effort to discuss the evolution of KM in the SC field	114 intra and inter-organizational performance metrics are reported within the SC context from an empirical data approach	*Papers published: 2008 – 2017, still needs updating *Mainly focused on KM processes, and performance metrics linked with KM initiatives - KM practices are not covered

2.5 Literature gaps and research questions

The systematic analysis of the literature performed in the early stages of this study makes it possible to single out relevant unexplored aspects that deserve further study. In this section, the main research gaps that emerged from the SLR, and the specific research questions that were formulated for this study, are described. In addition, further research gaps will be presented in the next section. Although these were not directly investigated in the thesis, they can still provide an interesting input for a future research agenda.

To summarize, the existing literature shows some criticalities. Primarily, while the term "KM practice" is often used, there is no consensus about a standard definition. This is the case of both KM in general, and its application to SC inter-firm relationships. Also, although this selection of papers explicitly focuses on KM in SCs, the notion of KM practice is often treated in a general way, and not necessarily with an emphasis on inter-firm relationships or SCs. Secondly, there is often a confusion between terms such as KM practice and KM process. The latter notion is important in the KM literature (Edwards, 2015) and is useful to distinguish between different basic activities of knowledge handling (for example, knowledge creation is different from knowledge transfer), but has little practical usefulness from a managerial viewpoint because it does not necessarily clarify what these activities imply in practical terms, namely, how they are or can be performed. Thirdly, while IT applications are generally considered an essential part of KM (Edwards, 2015), their role in KM practices is often controversial and unclear. Thus, comprehensive and clear classifications of practices with concrete meaning and application in business still lack. Moreover, the topic of KM practices for "SCs" is treated by only few studies.

Despite the considerable amount of research on KM on the one hand and on inter-firm relationships within SCs on the other hand, the in-depth literature review allowed us to detect the limitations of the current studies that connect the two fields. Particularly, it resulted that the literature is still very fragmented and lacks to provide standard definitions and classifications of KM practices, at both inter-firm and even intra-firm level. Though there are a few studies, as discussed in the previous section, that have categorized KM practices based on some criteria, these taxonomies are not consistent and there is no clear consensus on the typologies of KM practices that the companies can adopt. Especially, a literature gap is the lack of a clear and sufficiently comprehensive list of KM practices that can be used by firms to manage their knowledge not only internally but also in collaboration with business partners (in supply chains) for an effective inter-firm KM. In addition, the level of use of KM practices in

companies and inter-firm relationships has not been investigated sufficiently. Some studies (Centobelli et al., 2019; Cerchione & Esposito, 2017) tried to measure the intensity of use of some group of practices, but these are limited to particular contexts (namely, SMEs in Italy) and the list of practices considered did not cover the indirect (managerial) KM practices such as KM strategy, top management commitment, KM training, etc.. Based on these main gaps drawn from the analysis of literature, the following detailed research questions (RQs) were formulated for further investigation:

- *RQ1: What is or can be a knowledge management practice (i.e., what definition can be proposed)?*
- *RQ2: Which KM practices are mainly used or proposed for application not only in companies (internally) but also to inter-firm relationships in SCs, and how can be these practices categorized in a consistent way?*
- *RQ3: To what extent (i.e., level of adoption and intensity of use) these KM practices are exercised by firms?*

2.6 Additional research gaps

The present literature review also made it possible to identify an additional research gap, i.e., the lack of studies focused on factors (specifically KM barriers) influencing the implementation of KM practices by firms either at intra or inter-firm levels. As mentioned in section 2.2.4, very few studies have discussed barriers though there are some studies addressing KM enablers or success factors.

Despite the rising interest in the KM-SC area, the implementation of KM in SC inter-firm relationships can still encounter several barriers, which must be investigated since it can contribute both to the theory and the practice. On this issue, the current literature is very limited. As mentioned before, there are limited studies on KM practices exercised by firms in SCs, and on the associated potential factors affecting KM adoption and development in SCs (Cerchione & Esposito, 2016; H. Inkinen, 2016; Q. Li & Kang, 2019). Specifically, few studies on KM barriers in SCs (such as: Patil and Kant, 2014b, 2014a; Zerbino *et al.*, 2018; Batista *et al.*, 2019) are found but these have still a limitation in addressing the specific typical barriers associated with KM activities or initiatives. Also, it is necessary to remark that the studies have limited scope, insufficient empirical validation, and tend to present country specific cases. This shows that there is insufficient coverage of the possible challenges specific to KM related business activities. This also supports the findings of Cerchione and Esposito's (2016) review, which

argues that barriers to adoption of KM in SCs are scarcely analysed and there is a need for a systemic approach to identify and examine them.

Thus, an up-to-date review is needed. First of all, it can highlight the contributions and limitations of the previous studies. Second, identifying a comprehensive list of barriers and recategorizing them in line with a classification of KM practices could be an important research opportunity. The assumption here is that it will be easy for companies to manage both the adoption of certain KM practices and the associated barriers in parallel. From a practical viewpoint, a study on KM barriers, that hinder companies' effort to properly interact with SC partners for a collaborative learning, will provide lessons to managers on how to handle these barriers and improve practices for knowledge creation, sharing, protection, and KM application for a better firm and SC performances.

3. Proposed definition and ‘‘triple-category’’ classification of KM practices

3.1 Definition

To answer the first and second research questions, the systematic review of the literature (described above) with a further analysis of the content of additional relevant papers (i.e., including some important studies, explicitly focusing on KM practices but from an internally oriented perspective, which can be used to see the context of KM practices in general) was used. The lack of standard definitions and classifications of KM practices is an issue because it challenges any effort of researchers and practitioners to develop KM in business. It signals that there is the need of a common and comprehensive framework of definition and categorization of KM practices, not only in the case of interfirm relationships in SCs (which is the focus of this study) but even at a general level. To face these problems, a first step is providing a definition of KM practice in the context of business. Based on the analysis of the literature and feedback from some KM academicians, consultants, and experts (reviewers of KM journals), this study finally proposes the following notion for KM practices:

> *“A KM practice is one or more coordinated activities implying the use of methods to manage knowledge as a resource, and/or application of IT tools for KM, and/or use of other supporting management actions with the ultimate purpose to support the management of knowledge in business”*

KM practices in inter-firm relationships (in SCs) can be defined in the same way, but adding that, in these cases, they explicitly focus on “KM for collaboration between different companies and trading partners, involving the various stakeholders (in a SC)”, and not just on the management of knowledge in the single company from an internal-oriented perspective.

This definition underlines that KM practices:

- are activities explicitly targeted to manage knowledge as a resource, and not simply indirect or unconscious ways to handle knowledge
- must have a concrete relationship with the real problems of KM in business and the solutions that can be adopted to them and cannot be simply an abstract reference
- can include different approaches that are important for the management of knowledge, in line with a multi-dimensional view of KM (Dalkir, 2011; Edwards, 2015) which can

encompasses business goals and performances, people, processes, technologies, and organizational contexts

- in the case of SCs, they explicitly refer to practices that can support KM in inter-firm collaboration

3.2 Categorization and taxonomy of KM practices

The second step, next to providing a definition, is building a comprehensive classification of KM practices that can consider all the different typologies (Dalkir, 2011; Edwards, 2015) to provide the full picture of a KM practice. Here, a triple-category classification of KM practices is proposed (figure 6) where practices are divided into three main primary categories: KM methods, KM applications of IT, and KM-enabling management actions.

In this classification, the first category "KM methods" refers to practices that are explicitly and directly targeted to the management of knowledge resources in a company, such as: approaches to learning and exchanging knowledge contents; practical or mental toolboxes for favouring the systematization and access to knowledge resources; organizational arrangements which can be employed to facilitate knowledge sharing among people, etc. This category includes practices that are well known in the KM literature and are often considered "elective" KM practices. Specific examples that can be included in this category includes community of practices (CoPs), knowledge cafes, knowledge mapping, etc.

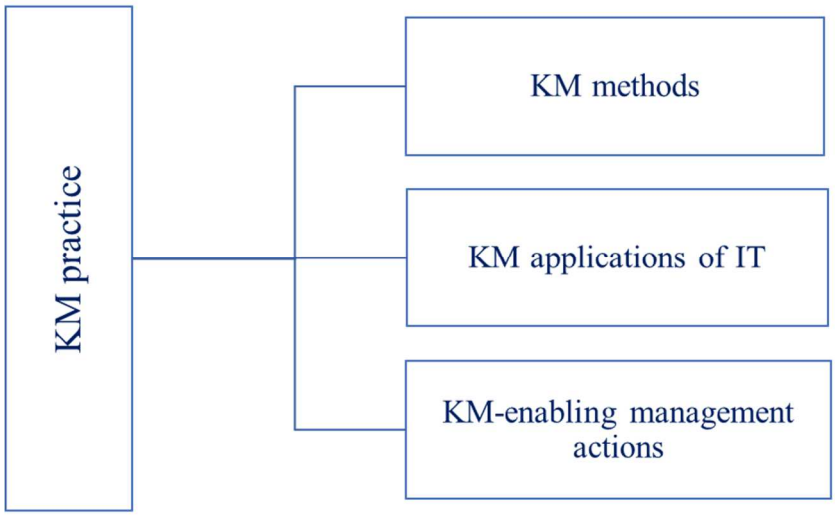


Figure 6. Triple-category classification of KM practices

The second category, "KM applications of IT", refers to the use of IT technologies/systems that can support the management of knowledge contents in some form – for example, explicit

knowledge in the case of database repositories and automatic analysis, or tacit knowledge in the case of communication-enabling systems. This category can include practices like the use of IT systems or platforms (e.g., shared databases, search engines, cloud computing, intelligent agents, supplier and customer relationship management platforms, etc.) to support the management of knowledge contents of some form. Here, we would like to clarify that the IT tools by themselves are not practices, rather the practice is the use of some selected IT system for a specific KM application. To provide a simple example, in the case of email systems, the use of these IT communication tools can be considered as a KM practice when the focus is on their support to the *transfer* or *sharing* of some *knowledge contents* (with internal employees and/or external SC partners, etc.). In this case, ‘‘the use of email systems to the transfer or sharing of knowledge’’ is considered as one of the ‘‘KM applications of IT’’ practices.

Concerning the third category, “KM-enabling management actions”, these are purposeful managerial activities that may not directly refer to the management of knowledge but, anyway, can help to set the appropriate organizational context that facilitates the application of KM - for example, appointing KM officers, rewarding KM initiatives, providing leadership and top management support to KM programs, etc.

This classification, unlike others, tried to provide a full picture of KM practices (Dalkir, 2011; Edwards, 2015) with a comprehensive list of specific practices under each category. Moreover, it can also be applied to inter-firm relationships (within SCs) for supporting KM activities in trading, knowledge sharing and in collaborative projects, mutual learning among partners, etc.

According to this classification, the analysis of the literature detected a total of 57 practices: 12 “KM methods” (mentioned in 8 papers), 22 “KM applications of IT” (identified in 14 papers), and 23 “KM-enabling management actions” (collected in 15 papers). The refinement of the initial list of these practices was conducted with experts working actively on KM, which include experts from both consultancy service and companies based in Italy and Spain. These includes: one international KM consultant and company’s KM team leader based in Italy (during interview about proposed definition, classification and questionnaire pilot testing), one company manager based in Spain (during questionnaire pilot testing), two KM professors based in one in Italy and the other in Spain (during interview for evaluating the questionnaire and proposed definition and classification, including lists of practices), five reviewers of a paper submission (feedback collected during review process of a paper, for publication, consisting of the proposed definition, classification and lists of practices with their importance to interfirm relationships in SCs), two company managers based in Spain (during interview for the survey

and to make further discussion on the applicability of the proposed lists of practices) and important feedbacks from conference (ECKM2020) participants (from both academicians and practitioners during review process and virtual presentation of a paper consisting of the SLR, the proposed definition and classification). All communications were made via videoconferencing and/or email communications tools due to the COVID19 pandemic which was a barrier to make it in a face-to-face conversation for a better discussion. Also, it is important to note that feedbacks from these different participants were collected in different time periods and circumstances, but generally from September 2020 to February 2021.

After a cross-analysis and revision of these lists, and getting feedback from KM experts and managers, to eliminate substantial replications and to highlight the focus on inter-firm relationships within SCs (which is the main topic of this study), there is a total number of 43 practices: 10 KM methods, 14 KM applications of IT, and 19 KM-related management actions.

After the categorization and revision of the list of identified practices, another important work was the development of a taxonomy of KM practices to give the complete picture together with the operational definition and the reference sources for each practice. In addition, given the objective of this thesis, the importance of each practice for its application to inter-firm relationships (in SCs) was also highlighted. The detailed results, refined and summarised after the inclusion of feedbacks of KM experts, which show the list of practices along with their conventional name, categorization, definition and potential importance for application to KM in SC are presented in table 6, table 7 and table 8.

Table 6. ‘‘KM Methods’’ and their importance for application to KM in SCs

KM Methods	Overall definition	Source	Application to inter-firm relations (in SCs)
Community of practice	Group of people sharing common interests, problems, or passions and discussing issues on ongoing basis.	(Centobelli et al., 2019; Kovács & Spens, 2010; Nikabadi, 2014; Venkatraman & Venkatraman, 2018; Ward & Wooler, 2010)	Used for collaboration, knowledge creation and sharing between representatives of SC partners through inter-firm communities/groups
Knowledge domain mapping	charting, mining, analysing, sorting, enabling displaying and browsing organization's knowledge	(Centobelli et al., 2017; Nikabadi, 2014; Ward & Wooler, 2010)	Easier knowledge access, revealing knowledge structures in knowledge flows; ensuring that knowledge reaches right people in SC processes
Lessons learnt	Documenting knowledge, learning from experience in a project	(Centobelli et al., 2019; Raisinghani & Meade, 2005; Scholten et al., 2019; Ward & Wooler, 2010)	Past experience helping joint project managers to reusing knowledge and avoiding repeated mistakes
Knowledge cafe´s	Frank exchange of ideas or views on a specific issue in groups to attain mutual understanding	(Centobelli et al., 2019; Lefika & Mearns, 2015; Ward & Wooler, 2010)	Helping joint project teams to create and exchange knowledge and improve SC innovation performance
Peer assist	Feedback/clarifications/lessons on a problem/issue among peers	(Cerchione et al., 2015; Lefika & Mearns, 2015; Ward & Wooler, 2010)	Facilitating knowledge sharing, participatory learning, and collective SC problem solving
Mentoring & coaching for knowledge retention	Guidance and learning between two individuals (mentoring) and developing specific skills (coaching)	(Centobelli et al., 2017, 2019; Lefika & Mearns, 2015)	Boosting knowledge transfer from coach/mentor to junior individuals in SC processes; retaining knowledge of leaving employees
Enterprise social network analysis	Analysing company’s social networks as an input for decisions	(Centobelli et al., 2019; Cerchione & Esposito, 2016; Ward & Wooler, 2010)	Collected information used to identify knowledge gaps as an input to support integration efforts between SC partners.

Case-based reasoning	Problem-solving method to capture and reuse experience in the field for new needs	(Almuiet & Zawaideh, 2019; C. Wang et al., 2008)	Solving new SC problems by retrieving past 'cases' describing similar prior problem-solving episodes; improving knowledge transfer in supply networks.
Online knowledge searches	Searching for knowledge on alternative online sources	(Nikabadi, 2014; Sher & Lee, 2004)	Knowledge acquisition method from different online sources to solve SC problems
Brainstorming	Encouraging individuals to generate creative ideas through group discussion	(Centobelli et al., 2017, 2019; Lefika & Mearns, 2015)	Generating ideas through joint team discussion of experts among SC partners; improving knowledge creation in collaborative partnerships

Table 7. ‘‘KM applications of IT’’ and their importance for application to KM in SCs

KM applications of IT	Overall definition	Source	Application to inter-firm relations (in SCs)
Data mining	Searching into large data sets for patterns and trends that can't be found with simpler analysis	(Centobelli et al., 2019; Liao et al., 2008; Lin et al., 2002; Szuster & Szymczak, 2016)	Extracting usable knowledge from different data sources across SCs and develop smart market or production decisions for the benefit of the entire SC
Video conferencing	Platform for remote meetings with integrated data sharing applications	(Centobelli et al., 2019; Lin et al., 2002; Nikabadi, 2014; Raisinghani & Meade, 2005)	Knowledge sharing in joint project teams for co-design, collaboration between SC partners and customers, reducing travel expenses and project times, improving communications of remote teams
Intelligent agents	Software for automatic decisions or information services, by learning from environment and user analysis	(Almuiet & Zawaideh, 2019; Liao et al., 2008; Lin et al., 2002)	Helping to capture and preserve tacit knowledge, discover knowledge, generate solutions by data analysis in a complex environment such as SC operations and joint project teams
Simple knowledge organization system (SKOS)	Semantic web technology to manage knowledge across SC in a machine-understandable way	(Cristian A. Rodríguez-Enríquez et al., 2016)	Ontologies and Web- based platforms facilitate KM among partners for reducing coordination costs in procurement and operations
Database systems and shared folders	Shared collection of interrelated data to meet varied needs of firms	(Centobelli et al., 2017; Mclaughlin, 2009; Nikabadi, 2014)	Facilitating knowledge storage, retrieval and sharing internally and in a company and across SCs
Enterprise resource planning (ERP)	Structured information systems to manage workflows in operational processes	(Centobelli et al., 2019; Scholten et al., 2019; Szuster & Szymczak, 2016)	Integrating information systems and processes, standardizing knowledge for operations and logistics in SCs, increasing online access to structured knowledge and decision making in SCs

Wikis	Corpus of knowledge in linked web pages, based on collective process of creation and editing	(Bertoni & Larsson, 2011; Nikabadi, 2014)	Integrating different elements of knowledge collectively created for transferring/sharing knowledge and improve learning and project management among SC partners.
Online forums	Online discussion site where people hold conversations via posts	(Bertoni & Larsson, 2011; Nikabadi, 2014)	Improving knowledge sharing among SC partners and joint project teams by means of conversations and informal language
Supplier relationship management (SRM)	Systems to assess suppliers' contributions to the business (in operations, and projects)	(Liang Chen et al., 2018; Tseng, 2014)	Helping companies and suppliers to work collaboratively, by means of joint knowledge creation and sharing, and enhancing the value created in the entire SC
Customer relationship management (CRM)	Systems that enable organizations to assess & gain a comprehensive view of their customers	(Liang Chen et al., 2018; Tseng, 2014)	Facilitate the creation of new knowledge about market demand and support a NPD process while customers and companies work collaboratively.
Cloud computing	Infrastructure for shared networks of storage, servers and applications over the internet.	(Centobelli et al., 2019; Cerchione et al., 2015; Szuster & Szymczak, 2016)	Facilitating access to data and applications from any location and device with cost savings; providing a more strategic approach for inventory deployment, operations monitoring and prioritization, etc.
Chat rooms and bulletin board systems (BBS)	In chat rooms people engage in real-time textual conversations; in BBS users share contents electronically	(Choi & Jong, 2010; Nikabadi, 2014; Raisinghani & Meade, 2005)	Helping SC partners to get or give immediate advice, to brainstorm, or get advice from experts; sharing public contents from a huge number of sources
Email and voice mail	Standardized asynchronous system for multiple format messaging	(Centobelli et al., 2019; Lin et al., 2002; Nikabadi, 2014)	Easily sharing rich knowledge contents with internal employees and/or external SC partners
Enterprise social media platforms	Web-based Internet platforms implemented within an organization for a rich content exchange	(Centobelli et al., 2017; S. B. Grant & Preston, 2019)	Improving visibility of business activities in the SC, building social relations between individuals across companies, facilitating informal knowledge exchange, mutual assistance of suppliers, customers, etc.

Table 8. ‘‘KM-enabling management actions’’ and their application to SCs

KM-enabling management actions	Overall definition	Source	Application to inter-firm relations (in SCs)
Knowledge strategy planning	Using Knowledge strategy as explicit part of its business strategy internally and/or regarding external partners	(Patil & Kant, 2016; Ruel et al., 2019)	Knowledge and KM become key elements of inter-firm strategies in SCs
Joint projects	Having Joint projects with practices to facilitate knowledge creation and exchange between participants	(Y. Li et al., 2012; Pérez-Salazar et al., 2019)	Joint teams in SCs are designed around KM goals
Top management support	Having a strong "Top management support" for KM programs, activities, and practices	(Patil & Kant, 2013; Shih et al., 2012)	Strong leadership at company and SC level facilitates knowledge sharing in SCs
KM officers	Assigning roles of Knowledge Management Manager/officer	(Navarro et al., 2010; Riege, 2007)	KM becomes a service provided to a company and its partners
Collaborative KM	Giving strong strategic focus and commitment for collaborative KM with trading partners, advisors, and consultants	(Y. Li et al., 2012; Scholten et al., 2019; Taher et al., 2017; Whitehead et al., 2019)	SC implies collaboration and knowledge sharing; knowledge can be acquired from cooperation with external partners
Strategic partnerships	Developing KM-based strategic partnership for managing knowledge resources between SC partners	(Whitehead et al., 2019; Wood et al., 2016)	Strategic alliances in SCs are built based on knowledge resources
KM investments	Allocating adequate resource for knowledge creation, storage, sharing and application activities	(Riege, 2007)	KM becomes a central investment for inter-firm relationships management in SCs
KM training	Providing KM-related training, education, and information programs	(He et al., 2019; Ruel et al., 2019; Scholten et al., 2019)	KM becomes integral part of SC trainings
Open sharing	Ensuring an organic structure supportive of open communication flows in all directions	(Riege, 2007; Zhao et al., 2012)	SCs become an environment for knowledge sharing

KM assessment	Having knowledge and/or information managers with strategic or action-based missions and regular assessments	(Ward & Wooler, 2010)	SC relationships are (also) assessed based on KM performance
Knowledge networking	Supporting existing networks for knowledge sharing following existing common interests	(Riege, 2007)	Informal networking is favoured as a way of improving SC collaboration
KM recognition	Incentive and recognition of Knowledge workers	(Q. Li & Kang, 2019; Liu et al., 2015; Riege, 2007)	Knowledge workers become key roles in SCs
Knowledge development	Systematic and planed knowledge acquisition or development through training and continuous education	(Cerchione & Esposito, 2016; He et al., 2019; Scholten et al., 2019)	Training programs are not restricted to a company but increasingly involve SC partners to acquire or disseminate knowledge about innovations, markets, etc.
Trust building	Building trust for favouring knowledge sharing	(Jean et al., 2014; Q. Li & Kang, 2019)	Trust as foundation of SC performances
Reducing knowledge leaking	Appropriate governance structure to reduce risk of leaking confidential knowledge internally or with external partners	(Q. Li & Kang, 2019)	Recognition of the value of knowledge in SC relationships
Knowledge protection	Using sound knowledge safeguard/protection measures to encourage knowledge sharing in SCs	(Cai et al., 2013; Jean et al., 2014)	Recognition of the value of knowledge in SC relationships and reduce knowledge likage
Knowledge communication	Timely and accurate knowledge communication to appropriate managers for strategic decisions	(Nguyen & Harrison, 2019; Shih et al., 2012)	SC management is based on a capability to acquire and use knowledge effectively
Rewarded knowledge sharing	Considering knowledge sharing practices as a part of regular staff development & performance reviews	(Patil & Kant, 2013; Riege, 2007)	Knowledge sharing as a recognized ingredient of interfirm relationships in SCs
Knowledge retention	Focus on employees leaving/retiring for retention of their knowledge of internal activities and/or external partners	(Ruel et al., 2019)	Recognition of senior managers' knowledge as a key element of inter-firm relationship management in SCs

4. Adoption and Use of KM practices: survey investigation

To address the third research question (to what extent the practices are exercised by firms) and strengthen the answers of the second research question, a survey approach was designed to empirically assess the adoption and intensity of use of the proposed list of KM practices. With this research, the aim of the study is not to investigate how firms adopt individual practices to achieve specific business goals, but rather to investigate to what extent the different KM practices are adopted and used by firms to manage their knowledge internally as well as in the relationship with their main suppliers and customers in a SC. From a scientific perspective, the achievement of this objective could fill the literature gaps highlighted earlier, and could provide an up-to-date overview of the KM practices used in firms in general and particularly in SC inter-firm relationships. From a practical viewpoint, a study of KM practices, that facilitates companies' KM effort to properly interact with SC partners for fruitful trading and collaboration, will provide lessons to managers on how to improve their practices for knowledge creation, sharing, protection, and KM application for better firm and SC performances.

To empirically assess the adoption and use of the proposed comprehensive list of practices, a survey approach with a structured questionnaire was adopted. Indeed, the use of surveys for confirmatory studies in business organization is widely justified considering the number of articles published in authoritative scientific journals in this field. To increase the response rate of our survey, the different techniques and recommendations made by Frohlich (Frohlich, 2002) are followed. In addition, the snowball sampling method was to some extent used, which is a non-probabilistic sampling technique that allows the sample size to grow as the selected individuals share and invite their social or professional circle to participate and so on (Goodman, 1961). The following sections present the unit and context of investigation, the survey design approach (structured questionnaire, measurement scale and items used), the sample, and the descriptive statistical approach followed.

4.1 Unit of investigation and research context

From the results of the literature review regarding the ‘‘unit of analysis’’ (i.e.: firm level, SC level, or supply network level), as presented in section 2.3.3, most of the studies were focused on a firm-level unit of analysis. Indeed, the analysis of KM issues at a SC or supply network level is clearly more difficult, especially with a statistical survey, as it is not easy to detect and

examine the KM practices in a SC across all the possible involved firms, thus this can be understood to be a point of weakness of many studies. But it may also reveal that KM practices in a SC may be adopted by trading partners (i.e., suppliers or customers) under the support or pressure of a major company in the SC (for example, a large manufacturer with its suppliers) (Attia & Salama, 2018; Y. Li et al., 2012; Samuel et al., 2011). By analysing the practices of these major companies, it is often possible to learn the KM practices that are used in the SC inter-firm relationships. In this context, it was decided that the unit of analysis for this study was the KM practices adopted internally and in the SC inter-firm relationships by the single company of the sample. Especially, to understand how knowledge is managed differently in the internal organizational context compared to the external inter-firm environment (specifically with suppliers and customers), the survey investigated both aspects. The target of the analysis is KM practices used by firms that are considered focal (i.e., leading) in their SC relationships to manage knowledge internally as well as in the relationship with their main suppliers and customers in their inter-firm relationship. Actually, there are also few firms that are probably non-focal in the sample, but these were also used. This is a necessary starting point to make the study feasible and realistically implementable, and also, being focal firms the core parts of a SC, studying their KM practices can provide information about the most important part of supplier-customer inter-firm relations (Albino et al., 1998; Y. Li et al., 2012; Samuel et al., 2011). Moreover, this is a new analysis that tried to fill the gap in the context of measuring the use of KM practices in an inter-firm relationship, and so it can be taken as an initial attempt.

It is also important to emphasize that the purpose is not specifically to examine KM in supply chains or in supply chain management but, rather, in inter-firm relationships, and supply chains are just a convenient and important context of analysis of inter-firm relationships. In other words, clients and suppliers, which have lots of interactions in their trading in SCs, are used as an opportunity to study inter-firm relationships.

4.2 Survey approach and sampling

Based on the research questions (RQ3 and partially RQ2) and the survey's context of investigation explained above, a draft of a structured questionnaire, using mainly the proposed list of KM practices presented in the previous chapter, was designed. After some refinements and revisions, it was sent to some KM consultants, experts and business executives (as mentioned earlier in section 3.2) for their evaluation as a pilot test. This was basically done, from December 2020 to January 2021, via videoconferencing and email communications due

to the COVID19 pandemic. In addition to the common feedback that can be provided during a pilot test of a questionnaire, such as clarity, understandability and manageability of the questionnaire to target survey respondents, other important feedback was also provided specifically on the need to merge and reorganize some of the practices and review their operational or application verbal explanations provided to respondents for clarity. For example, it was suggested that, under ‘‘KM applications of IT’’ category, “use of data mining’’ and ‘‘use of intelligent agents’’ merged into ‘‘use of artificial intelligence tools (e.g., data mining, machine learning, intelligent agents, etc.) for the automatic analysis of knowledge’’. Also, ‘‘use of wikis’’ and ‘‘use of online forums’’ were advised to be merged due to their similarity in application. Secondly, concerning items in the third category, ‘‘KM-enabling management actions’’, ‘‘strategic partnership’’ was advised to be considered with ‘‘collaborative KM’’, and ‘‘reducing knowledge leakage’’ was recommended to be merged with ‘‘knowledge protection’’ with a slight change in its verbal explanation: ‘‘use of knowledge protection techniques to reduce the risk of unauthorized disclosure and at the same time facilitate sharing between those who are authorized’’.

After considering the feedback provided with the pilot test, the final version of the structured questionnaire with 39 main elements (as shown in the appendix A) reflecting the proposed KM practice framework was developed. Each item was designed to assess the level of adoption and use of each practice by companies with reference to three distinct situations: internally, in relationships with suppliers, and in relationships with customers (or, at least, with their main suppliers and customers). This can help to understand the differences in the adopted practices (and the intensity of their use, see below) from one application context to another. A total of 10 practices with the KM-Method category, 12 practices with the KM applications of IT category and 17 practices with the KM-enabling management actions category were used to measure the level of use of the KM practices. All measures, with the exception of one item requiring a ‘‘yes / no’’ answer, were based on a five-point verbal frequency scale (Flynn et al., 1990) from 0 = don’t used at all to 4 = used very frequently. Respondents were asked to estimate which KM practices are adopted and with what intensity of use their companies are exercising KM practices internally and in relationships with their suppliers and customers. Indeed, the first point from the scale (0 value) is mainly used to indirectly trace which practices are not adopted by the investigated sample firms.

In the questionnaire, the operational definitions of the practices (items) were also included to help respondents, instead of mentioning only their conventional names (which may be too

technical especially for some of the practices). This can also contribute to reduce the bias to the responses given among the respondents (i.e., the difference in understanding of the practices and their specific applications to KM that could possibly happened if these operational definitions had not been provided and, without it, some of the practices will be too technical). The survey was conducted by using an online questionnaire with Google form, which was used to collect data through direct email contact with companies. A main source of contacts was LinkedIn, and especially the KM professional group LinkedIn pages. Other contacts were added by using a personal network of contacts of the PhD candidate and his supervisors. Typically, the data collection period ran from February 2021 to mid-June 2021. It seems like a long duration, but it was indeed a difficult time to reach respondents due to the impacts of the COVID-19 pandemic.

The survey covered a sample of large and medium-sized European manufacturing companies located in different countries (Italy, Spain, Germany, Switzerland, Netherlands and United Kingdom). We targeted manufacturing sector due to the reason that supply chains are clearly defined in this sector (Samuel et al., 2011). Regarding sampling, a "convenience sample" was used, which is a popular approach, especially given the descriptive nature of this research and the difficulty (especially in times of COVID-19 pandemic) to build a sample that statistically represents all companies of the population. As it can be seen from table 9, 66.7% of the companies are Italian, which could be due to the fact that the survey was also provided in Italian in addition to the English version.

Table 9. Classification of sample firms by country

Country	No. of firms	%
Italy	40	66.7%
Switzerland	2	3.3%
Germany	6	10.0%
Spain	7	11.7%
UK	3	5.0%
Netherlands	2	3.3%
Total	60	

As regards the type of companies, based on the size category, the response is mainly made up of large companies (75%) as reported in table 10. For this table, the classification of companies proposed by the European Commission (European Commission, 2005) is used. Basically, we

included midsize companies that only have more than 100 employees (i.e., we have rejected responses from SMEs with less than 100 employees) considering that supply chain issues may not be fully exercised in a small business. In addition to size (the larger companies), we also selected only manufacturing industries considering the objective of this study which is to address KM issues in SCs (client-supplier relationships).

Table 10. Classification of sample firms by size (employee bands)

Employees band	**No. of firms**	**%**
Medium (50-249)	15*	25.0%
Large (> 249)	45	75.0%
Total	60	

**Firms with >100 employees*

Concerning the types of companies, based on industry of operation, automotive, computer and electronics, and machinery were preferred on the basis of the inputs obtained from the literature review in which it was found that most of the authors focused their studies on these sectors. The classification of sample companies by main industry of operations (table 11) shows that most of the companies surveyed (68.3%: automotive, electronics, and plant and machinery) operate in a complex manufacturing industry in which it is expected that they use relatively more KM practices, at least within the sector, to improve their innovation activities due to the high global competition.

Table 11. Classification of sample firms by main industry of operations

Main industry of operation	No. of firms	%
Automotive	13	21.7%
Electronics	10	16.7%
Plant and Machineries	18	30.0%
Textile and clothing	3	5.0%
Food and Beverage	2	3.3%
Energy production and distribution	6	10.0%
Household appliances	2	3.3%
Construction materials	2	3.3%
Others	4	6.7%
Total	60	

Looking at the survey participants, priority was given to a KM manager/officer, if any in the company, and then to the CEO, general or plant managers, and SC and operations managers. In general, as demonstrated in table 12, most participants work in a role where they are supposed to be familiar with the overall KM and KM-related activities of the company (internally or with other companies in the SC), which makes them relatively appropriate for the survey.

Table 12. Classification of respondents by role in companies

Roles/job positions	%
CEOs/General managers/Plant managers	18.3%
KM managers/officers	20.0%
SC and operations managers	18.3%
R&D/project/innovation managers/directors	21.7%
IT/IS/ technology managers	6.7%
Marketing/sales managers	6.7%
Human Resource managers	8.3%

4.3 Descriptive statistical approach and the measures

To find out which KM practices are introduced in the companies and assess their degree of adoption, a measure was introduced: the ‘‘degree of spread (DoS)’’, which is calculated by dividing the number of companies adopting the specific KM practice by the total number of companies in the sample (Cerchione & Esposito, 2017). Regarding the main part of the third research question, the level of use of KM practices, ‘‘intensity of use (IoU)’’ - average value of the score attributed by a company to the frequency of use of each practice - was adopted as a measure of the level of usage of each practice by the investigated firms (Centobelli et al., 2019; Cerchione & Esposito, 2017). While the DoS shows the percentage of enterprises that use a specific KM practice, the IoU underlines whether the enterprises make little or intensive use of it.

Both DoS and IoU of each practice are calculated and analyzed, using excel spreadsheet software, separately for each of the three application situations, i.e., *internally, in relationship with suppliers*, and *in relationship with customers.* For example, DoS and IoU determination for practices found in the *KM-Methods category* and for *internal use / internal application situation* is presented in table 13.

Table 13. DoS and IoU of practices under the KM-Methods category and at internal use

Conventional names of KM practices (Methods)	Codes for Practices	Mean	SD	Degree of Spread (%)	Intensity of use
Lessons learnt	KM-M1	2.65	1.13	95.0	66.3
Knowledge cafes	KM-M2	2.20	1.42	80.0	55.0
Peer assist	KM-M3	2.72	1.09	96.7	67.9
Community of practices	KM-M4	2.32	1.28	90.0	57.9
Knowledge domain mapping	KM-M5	1.88	1.33	80.0	47.1
Enterprise social network analysis (ESN)	KM-M6	1.53	1.36	70.0	38.3
Mentoring and coaching for knowledge retention	KM-M7	2.15	1.35	86.7	53.8
Case-based reasoning	KM-M8	2.53	1.33	88.3	63.3
Brainstorming	KM-M9	2.78	1.08	96.7	69.6
Online knowledge searches	KM-M10	2.47	1.26	88.3	61.7

**Mean=average value of the ratings for the frequency of use of practices; SD=standard deviation which is used later to determine the coefficient of variation*

The same step is followed and both DoS and IoU for all practices under the three of the KM categories, separately at each of the three application situations, were determined and the results are presented in appendix B, tables B1 - B8. These tables helped to reach to the final compiled results, with tables (tables 14 for KM-methods, and, in appendix B, table B9 and B10 for the second and third categories) that are easier to visualise in parallel the DoS and IoU of practices under *all sections of use/application situations* and use the results for further analysis. Having these statistical values, different descriptive statistical analyses are carried out and the results are reported and discussed in the following chapter.

Table 14. DoS and IoU KM-Methods (at all application situations)

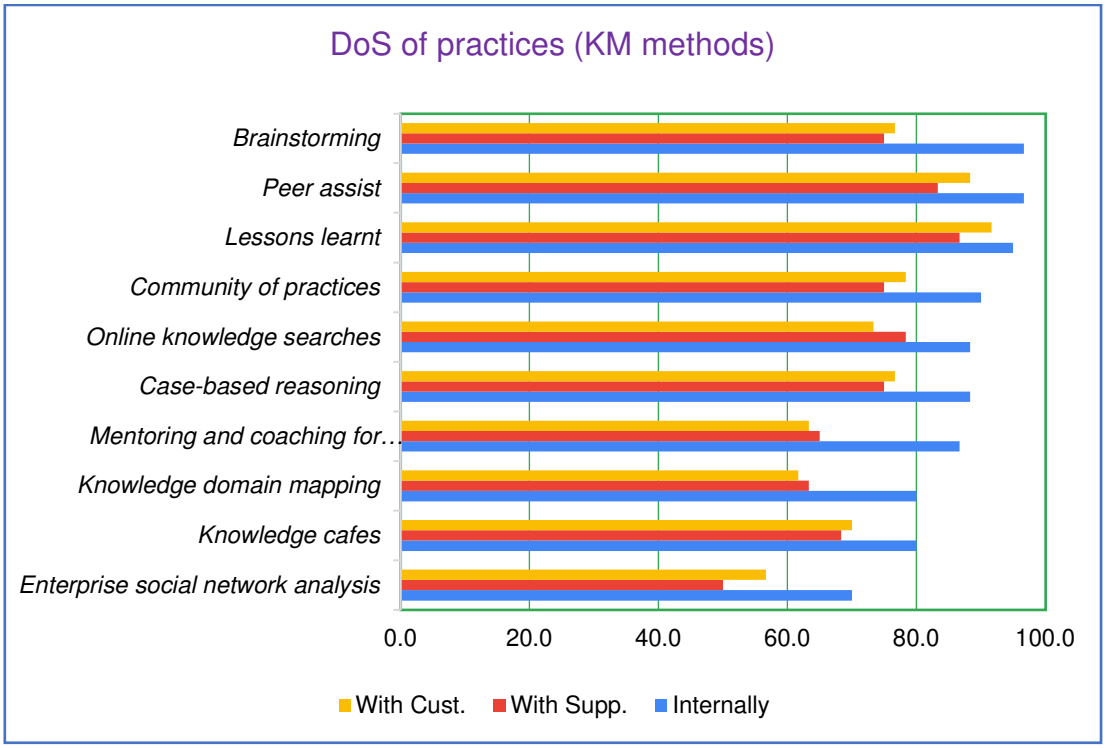
Conventional names of KM practices (Methods)	**Degree of Spread (%)**			**Intensity of Use**		
	Internally	With Suppliers	With Customers	Internally	With Suppliers	With Customers
Lessons learnt	95.0	86.7	91.7	66.3	51.7	57.5
Knowledge cafes	80.0	68.3	70.0	55.0	33.3	34.6
Peer assist	96.7	83.3	88.3	67.9	43.8	49.6
Community of practices	90.0	75.0	78.3	57.9	32.9	36.7
Knowledge domain mapping	80.0	63.3	61.7	47.1	27.1	27.1
Enterprise social network analysis	70.0	50.0	56.7	38.3	23.3	30.0
Mentoring and coaching	86.7	65.0	63.3	53.8	30.8	31.3
Case-based reasoning	88.3	75.0	76.7	63.3	42.1	46.7
Brainstorming	96.7	75.0	76.7	69.6	42.1	41.7
Online knowledge searches	88.3	78.3	73.3	61.7	44.6	40.0

5. Survey Results and Discussion

5.1 Analysis of the degree of spread (adoption) of KM practices

In this section, a statistical analysis is presented to examine which KM practices, from the proposed one, are introduced by firms and how much percentage of the investigated firms have adopted each practice (degree of spread) to manage their knowledge in the three different situations, i.e., internally, in relationship to their suppliers and customers.

As the chart in figure 7 displays, more than 50% of firms have adopted all ‘‘KM Methods’’ to manage knowledge internally, in relationship with their suppliers and customers. Looking to the degree of spread of each practice, practices such as Brainstorming, Peer assist and Lessons learnt found with a higher degree of spread (more than 95% internally and more than 75% at inter-firm level) whereas, Knowledge cafes, Enterprise social networks (ESN) analysis and Knowledge domain mapping relatively got a lower value of degree of spread (less than 80% internally and less than 69% at inter-firm level), i.e., they are adopted by relatively few number of firms to manage knowledge in business.



*With Cust. = in relationship with customers; Supp. = suppliers

Figure 7. Degree of spread of KM practices (Methods)

Looking at the adoption of KM practices in the second category, ‘‘KM applications of IT’’ (figure 8), all the practices are also found adopted with a degree of spread higher than 50% except two practices, artificial intelligence (AI) systems and SKOS. The degree of spread of these practices at the internal application situation is found to be greater than the spread at the inter-firm level. Of course, this is expected with most of the practices as any business begins implementing any practice internally first and then extends it for the use in an inter-firm relationship or across the supply chain.

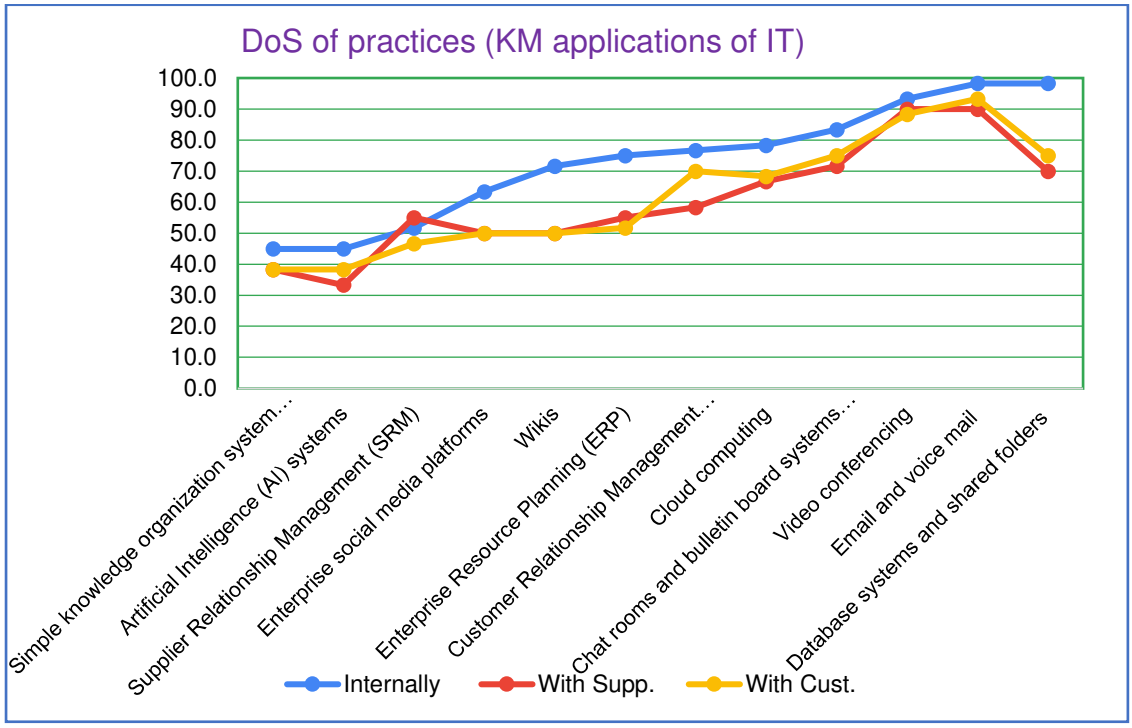


Figure 8. Degree of spread of KM practices (KM applications of IT)

Like the adoption of the practices in the first two categories of KM practices, as described before, all practices in the third category, ‘‘KM-enabling management actions’’, are also found adopted by the sample firms (figure 9). For intra-firm application, all practices are found adopted by more than 55% of the sample firms, and even in managing knowledge in relationship with suppliers and customers, all practices are adopted with more than 50% of the firms except some practices like KM recognition, KM assessment and KM training which are found with less than 50% degree of spread.

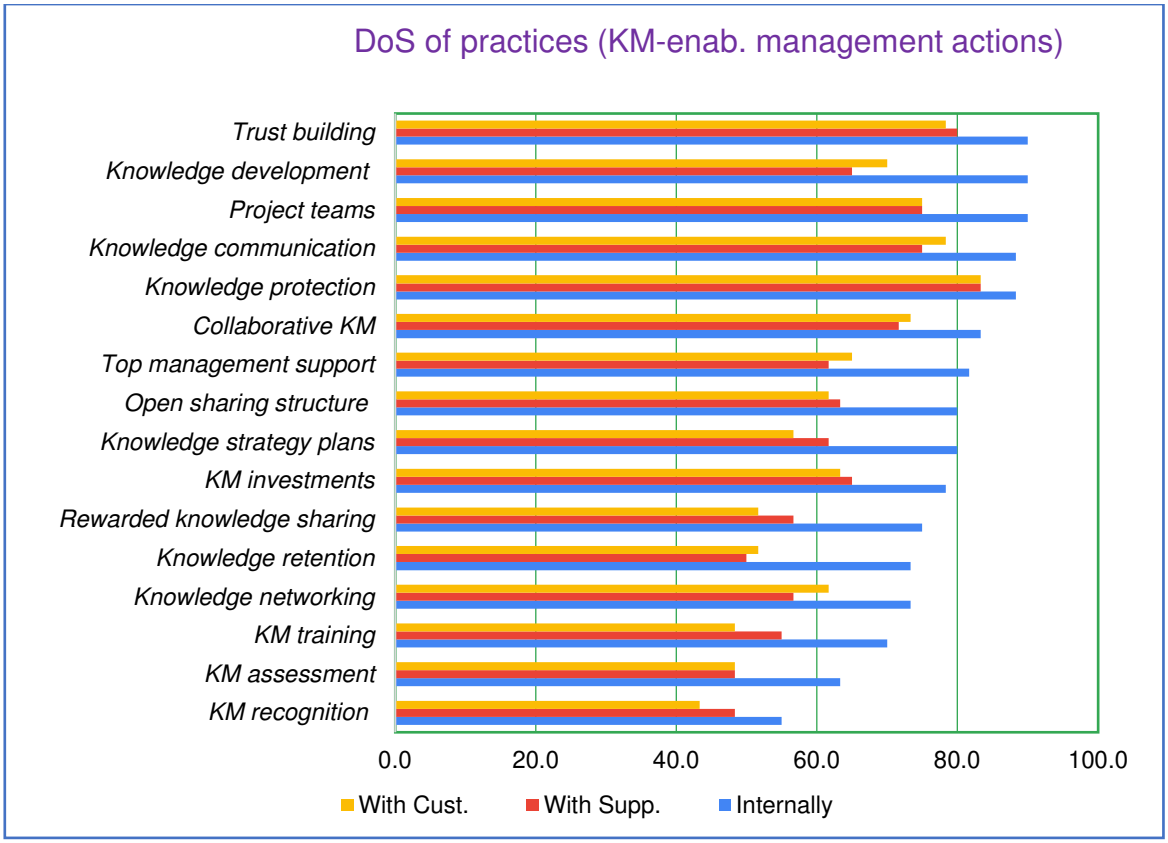


Figure 9. Degree of spread of KM practices (KM enabling management actions)

Generally, the analysis of the degree of spread of KM practices by the sampled firms showed that all the proposed practices are known and adopted, to some extent, at all application situations: internal and inter-firm (in the relationship with suppliers and customers), i.e., no single practice is found non adopted by all sampled firms. But generally, the adoption of the practices is with a very varied degree of spread (at inter-firm level) ranging from:

- 58.9 (ESN analysis) to 91.1 (lessons learnt) with a mean value of 77.6 for KM-methods,
- 38.9 (AI systems) to 93.9 (email and voice mail) with a mean value of 65.4 for KM application of IT practices,
- 48.9 (KM recognition) to 85.0 (knowledge protection) with a mean value of 68.5 for practices related to KM-enabling management actions.

When the adoption of the practices is compared among the three categories, it can be noticed that the ‘‘KM methods’’ exhibit a higher degree of spread, i.e., higher mean score value (77.6). With respect to the adoption of practices to manage knowledge in the relationship with

suppliers and customers, the lowest degree of spread is observed with the KM applications of IT practices where the lowest record of the practices reads at 33.3% for AI systems.

5.2 Measuring the intensity of use of the KM practices

5.2.1 Intensity of use of practices - ‘‘KM methods’’

As depicted in figure 10, the use of practices found in the KM method category, almost all practices except ESN analysis (38.3) and Knowledge domain mapping (47.1), exhibit an intensity of use of above-average value while used to manage knowledge internally. But, in the case of using these practices to manage knowledge in relationship with suppliers and customers, all practices except lessons learnt (51.7 with suppliers and 57.5 with customers) got almost below an average intensity of use (i.e., below 50). Table 15 also shows the summary of the statistical values for the practices in the KM methods category which are found with the lowest and highest IoU, and the mean score value and the coefficient of variation (CV) of KM methods in general when used to manage knowledge at each application situations. Compared to the use of practices at the three of the application situations, the internal intensity of use (the blue color line in figure 10) is a bit far from the use of practices in relationship with suppliers or customers. This indicates that companies are still focusing on internal knowledge management but limited at the inter-firm level.

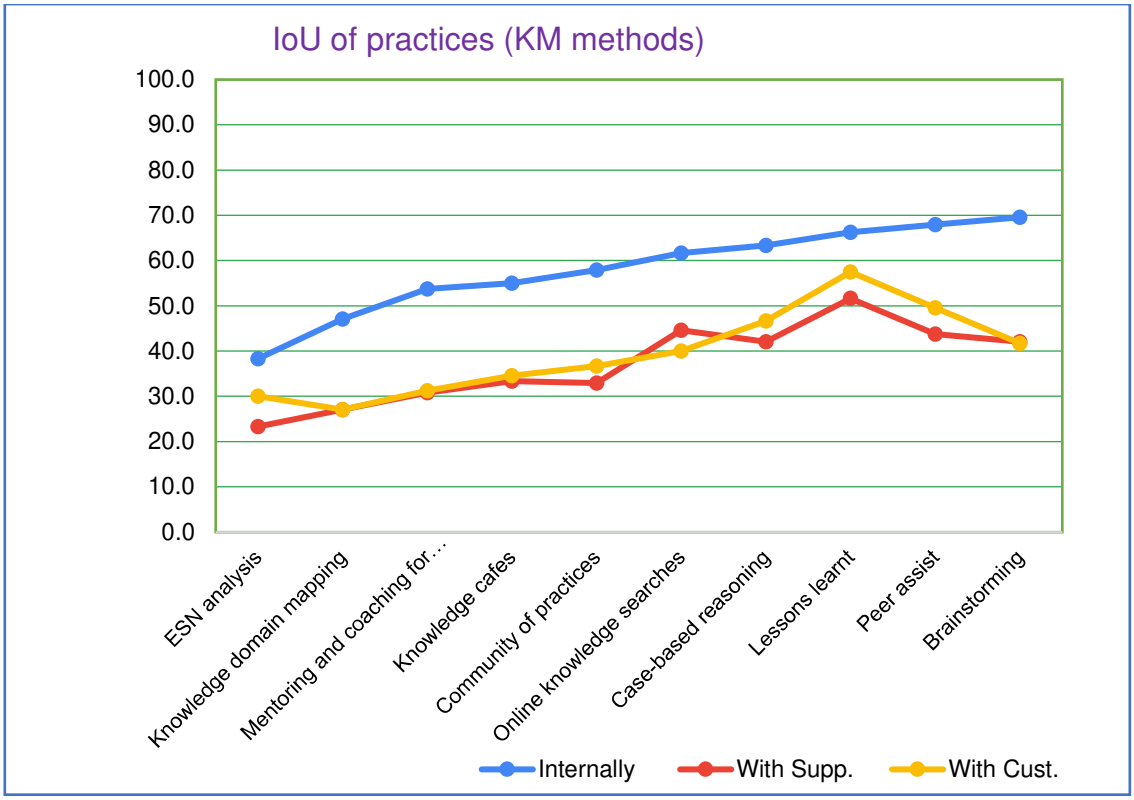


Figure 10. Intensity of use of KM practices (KM Methods)

From the statistical values (table 15), it can be seen that the lower value of CV (54.3%) indicates that the intensity of use of KM-methods internally shows a relative homogeneity than the use of practices in relationship with suppliers and customers. In other terms, there is a higher heterogeneity in the use of KM methods at inter-firm level. Furthermore, as it can be realized from figure 10 or the average values of table 15, companies are practicing KM methods more to manage knowledge in the relationship with customers than with suppliers. Another important comment from this analysis is that there is a small difference in the IoU of practices between customer and supplier relationships (yellow and red lines in figure 10) and the practices that are more popular internally are those that are more popular for interfirm relationships, except in the case of brainstorming. Also, some very popular KM methods like CoPs are not much used in inter-firm relationships. Generally, these points deserve further analysis, and that it may be interesting to understand if there is some relationship between some knowledge-based characteristics of methods and their IoU (for example, if they are devoted to explicit or tacit knowledge, or what processes are targeted, etc.)

Table 15. Summary of statistical values for the IoU of KM methods

Statistical items	Intensity of Use		
	Internally	**With suppliers**	**With customers**
Min	38.3 (ESN analysis)	23.3 (ESN analysis)	27.1 (Knowledge domain mapping)
Max	69.6 (Brainstorming)	51.7 (Lessons learnt)	57.5 (Lessons learnt)
Mean	58.1	37.2	39.5
CV	54.3%	81.9%	78.5%

**CV=coefficient of variations determined by dividing the mean values of the SD to the intensity of use*

5.2.2 Intensity of use of practices - ‘‘KM applications of IT’’

Figure 11 highlights that the intensity of use of KM-applications of IT practices ranges from 16.3 (AI systems) to 81.3 (Database systems and shared folders). Here, it can be observed that there is a relatively lower IoU for KM-IT practices (across all application situations) than the KM methods, and the minimum IoU (less than 20) for a specific practice is recorded in this category. This can also be seen from Table 16 which reports the summary of the statistical values for the IoU of the practices in this category. Again, there is higher variation in the intensity of use of KM-IT practices compared to the IoU of KM-Methods, in which the CV shows up to 94.2% (table 16). This variation can be illustrated with the case where some practice groups such as email and voicemail, video conferencing, and shared folder and database systems have an IoU greater than 70, while another practice group such as SKOS, artificial intelligence systems and SRM achieved an IoU of less than 30. The IoU of the remaining KM-IT practices lie between the IoU of the above two groups or roughly around the average value.

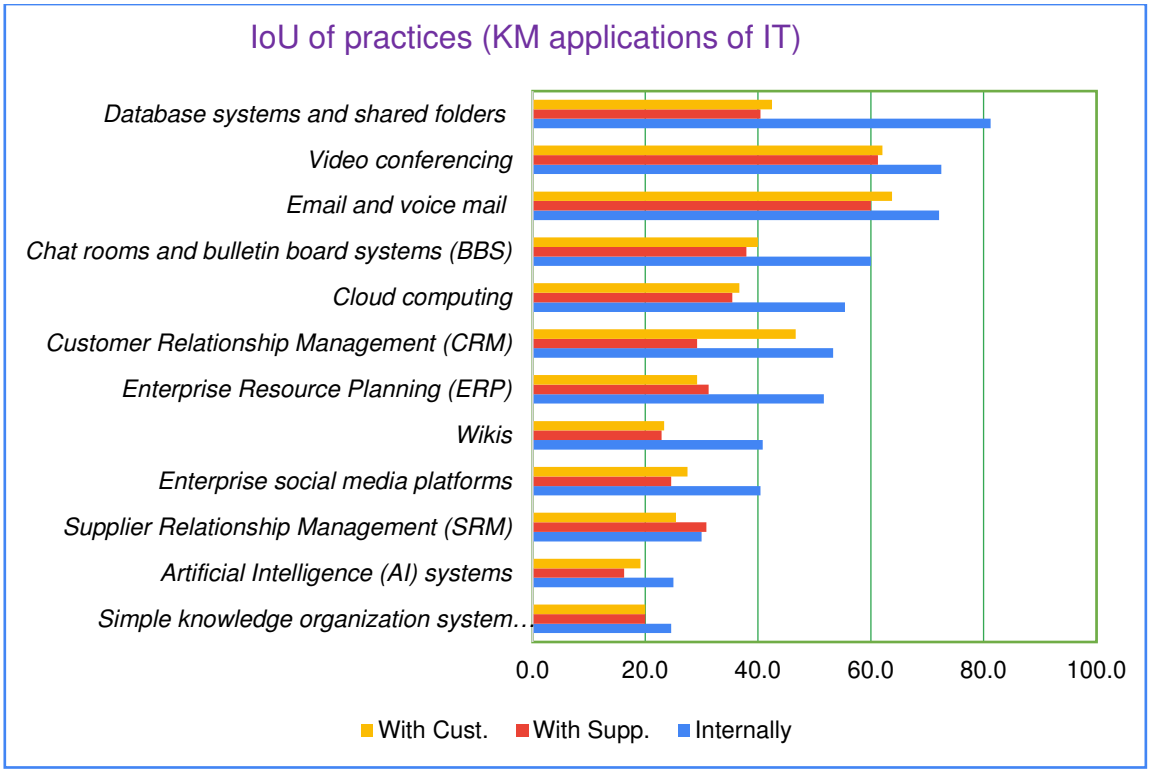


Figure 11. Intensity of use of KM practices (KM applications of IT)

Some further comments that can be interesting to make here includes:

- More complex systems like AI are less common while others like email are mostly used, which can be easy to understand.
- For some systems, it is easy to understand the situation, for example CRM is used with customers than suppliers, and the opposite with SRM.
- Videoconferencing and email are almost similarly used internally and externally, but in other cases it is difficult to explain for example share folders or cloud computing (in principle, why not much in inter-firm relationships?).
- Another comment is that, compared to KM-methods, as regards IT there is a clearer characterization (while in KM-methods there was nearly the same IoU with customers or suppliers, here there are some visible differences).

Table 16. Summary of statistical values for the IoU of KM applications of IT

Statistical items	Intensity of Use		
	Internally	**With suppliers**	**With customers**
Min	24.6 (SKOS)	16.3 (AI systems)	19.2 (AI systems)
Max	81.3 (DB systems)	61.3 (Video meetings)	63.8 (Email & voice mail)
Mean	50.6	34.2	36.4
CV	67.8%	94.2%	90.3%

5.2.3 Intensity of use of practices - ‘‘KM-enabling management actions”

Like the above discussed IoU of practices in the two categories, figure 12 also presents the level of use of practices in the KM-enabling management actions category, which ranges from 20.0 (KM recognition) to 70.4 (Project teams). The IoU for this category exhibits a lower value compared to the IoU of KM-methods and KM applications of IT practices. As shown in figure 12, this can be illustrated in the case in which the intensities of use of all practices for the inter-firm application, to manage knowledge in the relationship with suppliers and customers, apart from the knowledge protection (60), are exercised at an almost below average levels of use.

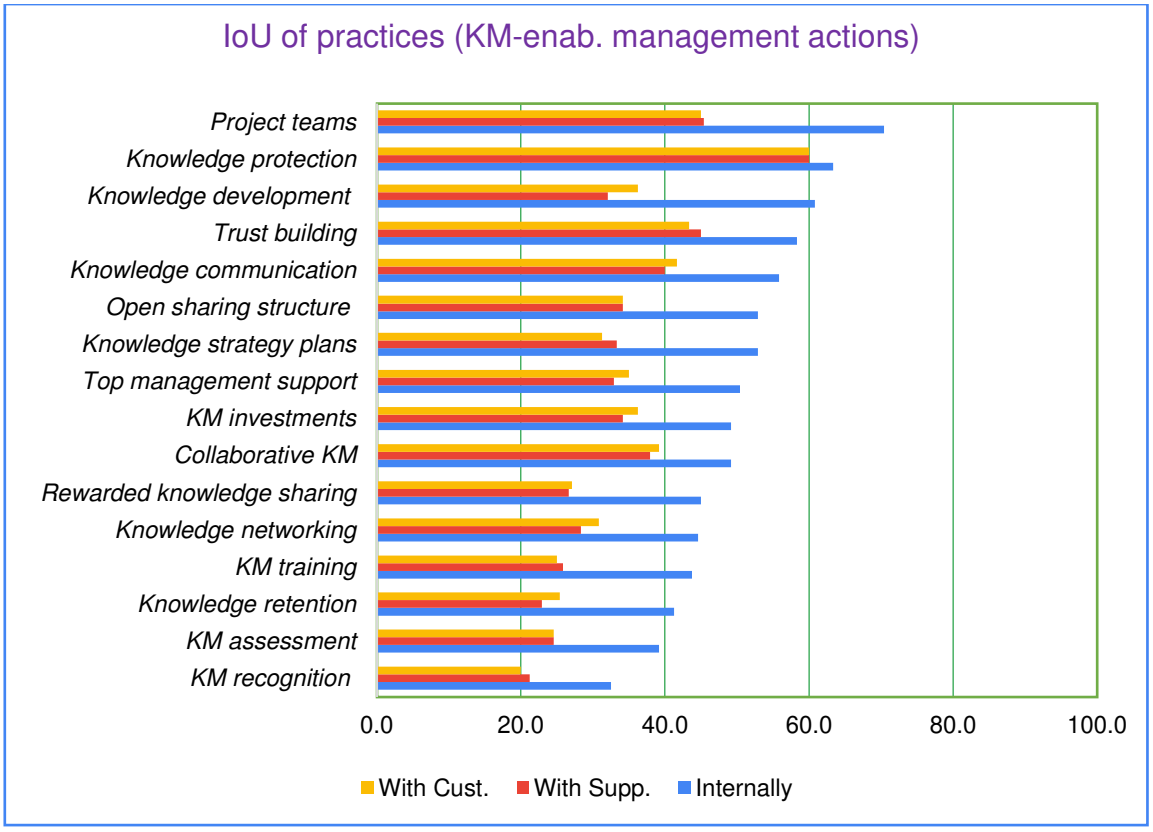


Figure 12. Intensity of use of KM practices (KM-enabling management actions)

As illustrated in table 17, the summary of the statistical values for the IoU of practices in this category, the higher CV (up to 94.9%) indicates that there is a heterogeneity in the usage of these practices. Unlike to the practices in the other two KM-practice categories, in this category, the same practice (knowledge recognition) appears at both internal and inter-firm applications and with the minimum IoU value. This signals that, in the surveyed firms, there is still poor encouragement and reward (with incentive and recognition mechanisms) to the activities of "knowledge workers" who work within and/or in collaboration with external partners (suppliers and customers).

Table 17. Summary of statistical values for KM-enabling management initiatives

Statistical items	Intensity of Use		
	Internally	**With suppliers**	**With customers**
Min	32.5 (KM recognition)	21.3 (KM recognition)	20.0 (KM recognition)
Max	70.4 (Project teams)	60.0 (Knowledge protection)	60.0 (Knowledge protection)
Mean	50.6	34.5	34.3
CV	67.5%	93.5%	94.9%

5.3 Discussion and summary of main findings

To sum up the analysis and the important results related to the use of KM practices and to highlight main findings by comparing the results between firm and inter-firm relationships (customer-supplier relationship in SCs), the average IoU is used here as for the inter-firm application situation. Accordingly, we draw the following summarized pictures and then the interpretations are discussed. The IoU of practices at inter-firm level, like it has mentioned earlier for each of the three application situations at each KM categories earlier, are varied which ranges from:

- 30.6 (ESN analysis) to 58.5 (lessons learnt) with a mean of 44.9 and CV of 71.6% for practices in ‘‘KM-methods’’,
- 20.1 (AI systems) to 65.3 (email) with a mean of 40.4 and CV of 84.4% for practices in ‘‘KM application of IT’’, and
- 24.6 (KM recognition) to 61.1 (knowledge protection) with a mean of 39.8 and CV of 83.8% for practices related to ‘‘KM-enabling management actions’’.

Looking at these three IoU values of KM practices, it is happened that ‘‘KM-methods’’ are used, on average, more intensely than ‘‘KM applications of IT’’ and ‘‘KM-enabling management actions’’, both at firm (as shown in the previous analyses from section 5.2.1 - 5.2.3) and interfirm level. This finding supports also the results of other related studies (Centobelli et al., 2019; Cerchione & Esposito, 2017) though their studies are limited to some practices found only in the first two categories and in a case of SMEs in a single country. This is a point that deserves further study. In particular, someone may be surprised to see that IT is less used than “organizational” KM methods while many people say that KM is just a matter

of IT, but the results of this study and the above mentioned two related studies appear to contradict this.

The intensity of use of practices at inter-firm level, in general, is low where all the mean score IoU values for the three of the KM categories are found below an average level of use (IoU below 50). Of course, in case of the use of these practices to manage knowledge at intra-firm level, the figures (as depicted in tables 15, 16 and 17) show that it is more or less above the average level of use. However, the result also depicts that the level of use of the practices when they are used by firms to manage knowledge in the relation to suppliers and customers, inter-firm level, is a bit far from the internal level of use (except few practices like knowledge protection and SRM which have showed approximately similar measures at intra or interfirm). Though it deserves further analysis, this may signal that firms are not exercising adequately the KM practices to manage their knowledge in collaboration with SC partners (at least with their suppliers and customers) which in turn affects the benefits they can gain from the inter-firm learning. Indeed, it is not easy to manage knowledge along a SC, across all the possible involved firms, like managing knowledge in a single firm. However, it may also reveal that one can start adopting KM practices in a SC by first adopting them by business partners (suppliers or customers) under the encouragement or pressure of a major company in the SC (for example, a large manufacturer with its main suppliers or customers).

Another point that can be drawn from the above analysis is that the high values of the coefficient of variation indicates that the IoU of the different KM practices at inter-firm level is heterogeneous. This means that most of the KM practices have an IoU which is varied or not around the average value. It may be due to the reason that most of the firms prefer or stick to use mostly the older and/or the common practices which are also used to manage other business activities, other than KM activities. In this case, the firms' use of the updated and specific practices applicable to KM is limited. Another possible reason is that the level of awareness of firms about the KM practices could be different.

In order to aware companies or researchers for a further action, looking into the nature of the practices frequently used, the top three intensely used practices from each KM categories are identified and the summary of it is presented below in table 18 for a further analysis.

Table 18. Top three intensely used KM practices

Category for KM practices	Internally		Inter-firm level	
	Practice	**IoU**	**Practice**	**IoU**
KM-Methods	Brainstorming	69.6	Lessons learnt	58.3
	Peer assist	67.9	Peer assist	53.8
	Lessons learnt	66.3	Brainstorming	51.1
KM applications of IT	Database systems and shared folders	81.3	Email and voice mail	65.3
	Email and voice mail	72.1	Video conferencing	65.3
	Video conferencing	72.5	Database systems and shared folders	54.7
KM-enabling management actions	Project teams	70.4	Knowledge Protection	61.1
	Knowledge Protection	63.3	Project teams	53.6
	Knowledge development	60.8	Trust building	48.9

From this analysis, it can be simply observed that, generally, the practices that are more popular internally are those that are more popular for interfirm relationships. However, we can notice that firms make more intense use of KM-methods that are not exclusively dedicated to KM issues or practices which are also used for other managerial and organizational purposes (in addition to their use for KM purpose), such as lessons learnt, peer assist, or brainstorming. By contrast, practices geared to KM (such as: CoPs, knowledge café and knowledge domain mapping) present a lower IoU. Similarly, a larger part of firms surveyed are inclined to use the traditional KM applications of IT practices, such as email and voice mail, database systems and shared folders, and video conferencing (which showed highest IoU), rather than focusing to use intensely the updated ones, such as AI systems, cloud computing, enterprise social media platforms, CRM and SRM systems (found with lower IoU) that can help firms to go with the ICT technological dynamics. These two findings, i.e., the inclination of surveyed firms to use intensely the KM-methods that are not exclusively dedicated to KM issues and to use the traditional KM applications of IT practices, supports the findings of similar studies (Centobelli et al., 2019; Cerchione & Esposito, 2017) though their studies were with a case of SMEs and firm level unit of analyses.

Regarding the 3rd category, the appearance of practices like ‘‘KM development’’ and ‘‘project teams’’ among the top three intensely used practices is very promising to improve the KM implementation in the inter-firm relationships within supply chain whereas the third intensely used practice ‘‘knowledge protection’’, which is of course important to secure critical knowledge leakage, can be taken as a tradeoff since it may also limit the knowledge sharing process of a firm with its main partners. However, important practices under this category such as: KM recognition, Knowledge retention and KM training, that could facilitate even the use of other practices, showed lowest IoU. In general, the key finding here is that firms use less intensely those practices which are generally indicated to be “elective” by the KM literature and are fully geared to KM as is generally defined.

The survey results also helped to provide more information for the second research question, about the level of adoption and intensity of use of each practice (both at firm and inter-firm level) to the previously provided taxonomy of KM practices (section 3.2) – in other words, the relative importance of each practice. The summarized result is presented in table 19 and this could be important for both research and practice. These findings depicted, as it can be easily observable from table 19, that the most adopted practices (practices with a higher degree of spread) are also the most intensely used practices at both intra and inter-firm application situations.

Table 19. KM practices: list, degree of spread and Intensity of use

Category for KM practices	Conventional names of practices	DoS (%)		IoU	
		Firm	Inter-firm	Firm	Inter-firm
KM Methods	Brainstorming	96.7	82.8	69.6	51.1
	Peer assist	96.7	89.4	67.9	53.8
	Lessons learnt	95.0	91.1	66.3	58.5
	Case-based reasoning	88.3	80.0	63.3	50.7
	Online knowledge searches	88.3	80.0	61.7	48.8
	Community of practices	90.0	81.1	57.9	42.5
	Knowledge cafes	80.0	72.8	55.0	41.0
	Mentoring and coaching for knowledge retention	86.7	71.7	53.8	38.6
	Knowledge domain mapping	80.0	68.3	47.1	33.8
	Enterprise social network analysis	70.0	58.9	38.3	30.6
KM applications of IT	Email and voice mail	98.3	93.9	72.1	65.3
	Database systems and shared folders	98.3	81.1	81.3	54.7
	Video conferencing	93.3	90.6	72.5	65.3
	Chat rooms and bulletin board systems (BBS)	83.3	76.7	60.0	46.0
	Cloud computing	78.3	71.1	55.4	42.5
	Customer Relationship Management (CRM) systems	76.7	68.3	53.3	43.1
	Enterprise Resource Planning (ERP)	75.0	60.6	51.7	37.4
	Wikis	71.7	57.2	40.8	29.0
	Enterprise social media platforms	63.3	54.4	40.4	30.8
	Supplier Relationship Management (SRM) systems	51.7	51.1	30.0	28.8
	Simple knowledge organization system (SKOS)	45.0	40.6	24.6	21.5

	Artificial Intelligence (AI) systems	45.0	38.9	25.0	20.1
KM-enabling management actions	Project teams	90.0	80.0	70.4	53.6
	Knowledge development	90.0	75.0	60.8	43.1
	Trust building	90.0	82.8	58.3	48.9
	Knowledge protection	88.3	85.0	63.3	61.1
	Knowledge communication	88.3	80.6	55.8	45.8
	Collaborative KM	83.3	76.1	49.2	42.1
	Top management support	81.7	69.4	50.4	39.4
	Knowledge strategy plans	80.0	66.1	52.9	39.2
	Open sharing structure	80.0	68.3	52.9	40.4
	KM investments	78.3	68.9	49.2	39.9
	Rewarded knowledge sharing	75.0	61.1	45.0	32.9
	Knowledge networking	73.3	63.9	44.6	34.6
	Knowledge retention	73.3	58.3	41.3	29.9
	KM training	70.0	57.8	43.8	31.5
	KM assessment	63.3	53.3	39.2	29.4
	KM recognition	55.0	48.9	32.5	24.6

In the survey questionnaire, there were also two other questions with ‘‘yes/no’’ response (as shown in the Appendix A), one concerns the availability of a dedicated KM office, and the second question was to investigate whether the companies have assigned a manager to the role of Knowledge Manager / Officer / Leader (one of the practices listed in the third category of KM practices). From the summary of the responses to these questions, the results showed that only 26.8% of the sample companies have a knowledge management office and 41.1% of companies have assigned a manager to the role of Knowledge Manager / Officer / Leader. These figures, specially the former, indicates that the KM issue has not given enough attention by the firms to lead the KM activities and programs of the company strategically and organizationally with a dedicated KM office and related resources including KM personnel. This empirical finding supports the ideas raised by some of the KM practitioners during the interview that KM is a "luxury" in some companies and often the first to be cut when times are tough - given less attention.

5.4 Further analysis and results

While all the research questions have been addressed in the previous sections of the study, in this section, a further statistical analysis is conducted to carry out some additional investigations that could directly or indirectly reinforce our previous analysis and findings. Primarily, using the previous IoU results, a correlation analysis is made to see some relationships between the intensity of use of practices at firm and inter-firm level. Secondly, the adoption and use of KM practices is examined with respect to individual companies (the analysis made in the previous sections is with respect to individual practices which was the focus of this study) to highlight differences and similarities among the companies surveyed. Finally, another correlation analysis is made to investigate the relationship among the firms' use of the practices in the three of the categories of KM practices. Hence, the associated results and findings are presented and discussed briefly in the following sections.

5.4.1 Correlation analysis: the use of practices at firm and inter-firm level

To see the relationship between the use of practices to manage knowledge internally and at the inter-firm level (i.e., with suppliers and customers), a correlation analysis is conducted using the IoU values of the practices in each application situations. Looking at the three results of the correlation analysis as illustrated in figures 13, 14 and 15, it is important to note that a higher and positive correlations are found among the IoU of practices in the three of the relationships. The highest correlation ($r = 0.95$) is found between the IoU of the practices used in relationship with suppliers and customers, that is, the more intensely the practices are used by firms to manage knowledge in relationship with suppliers, the more likely the firms will intensely employ them to manage knowledge in relationship with customers (and vice versa).

In general, looking more deeply at the relationship between the use of practices at the company and intercompany level, the results of the correlation analysis signify that the more intensively the practices are used internally, the more the companies will intensively practice them to manage knowledge in the relationship with suppliers and clients, i.e., in interfirm relations in the SCs, which is also an important indication for both research and practice. In this aspect, when the level of intensive use of practices improved, this relationship will lead to the more implementation of the KM practices across the SC for a better inter-firm collaborative KM.

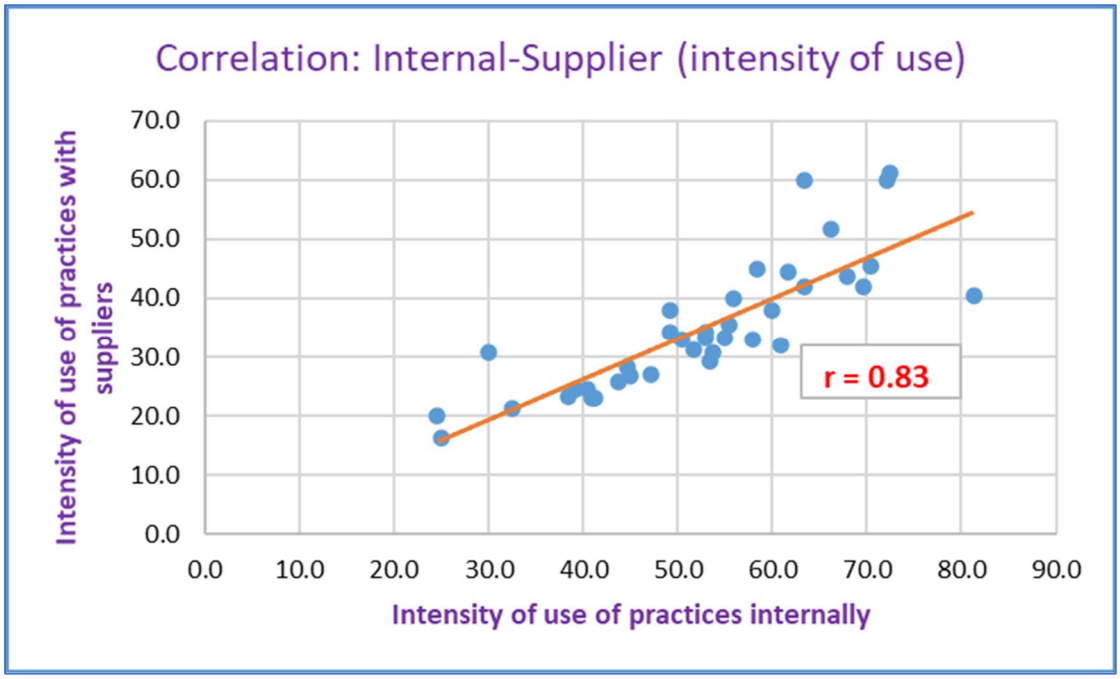


Figure 13. Correlation between the use of practices internally and with suppliers

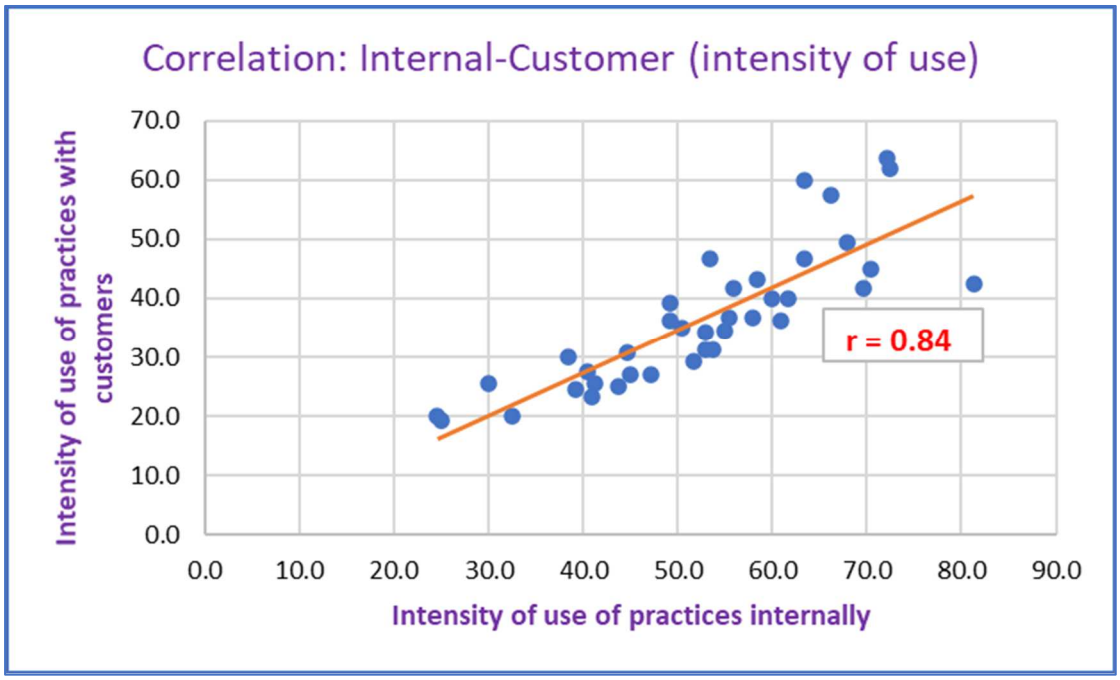


Figure 14. Correlation between the use of practices internally and with customers

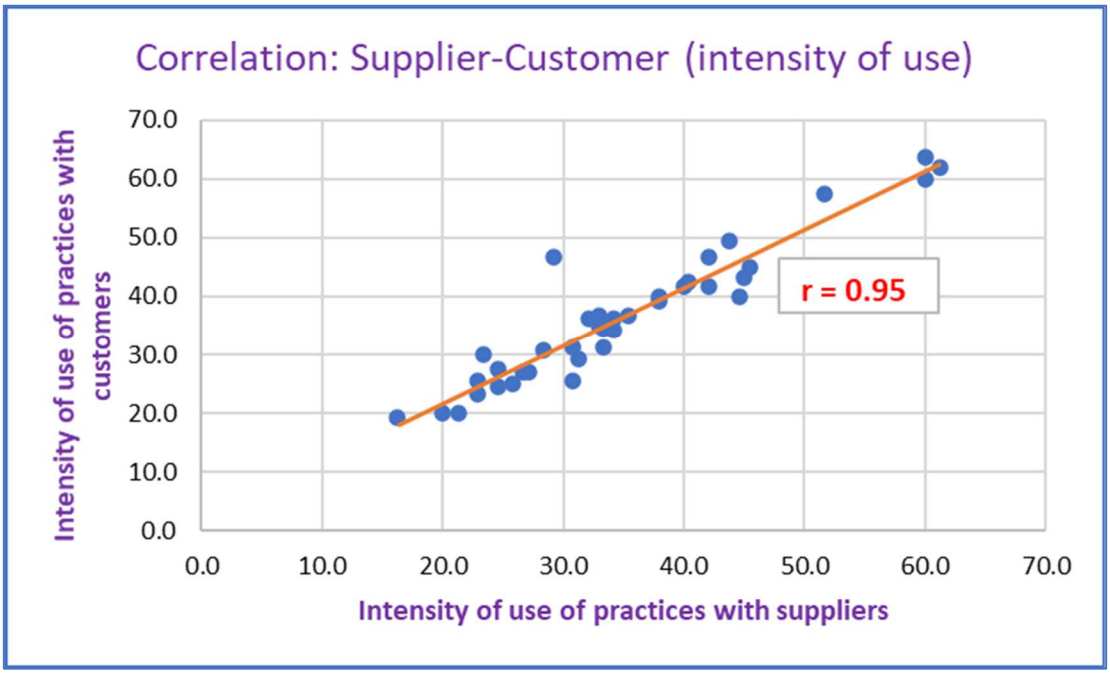


Figure 15. Correlation between the use of practices with suppliers and customers

5.4.2 Analysis of firms' adoption and use of practices and the relationship among the categories (with respect to individual firms)

In the previous parts of the analysis (sections 5.1-5.3 and 5.4.1), the degree of spread and intensity of use of KM practices were highlighted in the sample firms investigated from the point of view of each KM practice (i.e., to know which practice is adopted and at what degree of spread, the intensity of use of each practice, and which practices are most intensely used, etc). While this part focused on the analyses from the individual firm perspective, i.e., individual firms' adoption and intensity of use of the practices. This aims to underline the homogeneity or heterogeneity that can be appeared among the firms' level of use of KM practices (highlights differences and similarities among the firms examined). With this aspect, in this section, the relationship between the use of practices found in one of the categories compared to the use of practices found in the other category, i.e., the relationship that firm's adoption and use of the KM practices have among the three of the categories is also investigated.

For this purpose, the firm's ''differentiation index'' and ''intensity of use index'' were used as measures of firm's level of adoption and use of KM practices respectively. As it is explained and used in the studies (Centobelli et al., 2017; Cerchione & Esposito, 2017), the index of

differentiation (IoD) is simply the ratio between the number of KM practices adopted by the individual firm and the total number of KM practices proposed by the study. The percentage values of it can range from zero, if no KM practice is adopted by the firm, to one hundred, if the firm adopted all the proposed KM practices. Whereas the intensity of use index (IoUI) is obviously an individual firm's mean score value for the frequency of use of all the KM practices adopted by that firm. Here, the two indexes were calculated for each firm in each of the three of the categories of KM practices as presented in table 20 and 21. These tables show the firms' IoD and IoUI values at inter-firm level which are actually compiled after both the measures are analysed for each firm at each category and each application situations.

5.4.2.1 Firms' IoD of KM practices and the relationship among the categories of KM practices

As shown in table 20, even though the firms' adoption levels of practices at each application situations (i.e., internally, with suppliers or with customers) are different, it is presented here only the summarised values for the inter-firm level (average values for the IoDs of the three application situations) in order to see the inter-firm relationships aspect. This will not have a significant problem since the focus of the analysis here is not based on a comparison between intra and inter-firm cases, rather a comparison is done among the three categories. So, in this case, the analysis can be done by taking any of the IoD values of the three application situations or the average of them (as considered in this study to favour the inter-firm aspect). Accordingly, the index of differentiation of KM practices (as depicted in table 20) ranges from 30 (a firm that adopted only 3 KM-methods from the total proposed 10 KM-methods) to 100 (a firm that adopted all of the KM-methods, of which 28.3% of investigated firms at inter-firm level and 50% of firms at internal use) with a mean of 78.5. Similarly, IoD of firms for the second category ranges from 30.6 (a firm that adopts only 4 out of the total proposed 12 KM applications of IT practices) to 100 (a firm that adopts all the KM-IT practices, of which 13.3% of firms at inter-firm level and 21.7% of firms at internal use) with a mean of 67.5. Also, for the third category, IoD of firms ranges from 27.1 (a firm that adopts only 5 out of the total proposed 16 KM-enabling management actions) to 100 (a firm that adopts all the proposed KM-enabling management actions, of which 15% of firms at inter-firm level and 30% of firms at internal use) with a mean of 70.8. From these summarized statistical values, though the firms' level of adoption of practices (IoD) which ranges from the minimum values of 27.1 - 40 (F20, F27, F33) to 100 percent (on average, about 33% of firms at internal use and 19% of

firms at inter-firm application) seems the presence of heterogeneity (high variation) among the firms, it is not really because of a true variation but because of the presence of few firms adopting few practices. This can be explained by the fact that the mean values, which are all above 67 implying that majority of the firms adopted most of the proposed practices, and a relatively lower CV values are found (26.1, 32.5, 33.7 for methods, IT practices and supporting management actions respectively). Another important finding, specially looking at the mean values, is that the firms' adoption level of the proposed KM practices in general, irrespective of the intensity of use, is good and promising for future successful introduction and development of KM programs.

Table 20. Firms' Index of differentiation of KM practices

Firms	IoD of KM practices		
	KM-Methods	KM applications of IT	KM-enabling management actions
F1	86.7	88.9	75.0
F2	63.3	86.1	97.9
F3	50.0	41.7	39.6
F4	76.7	47.2	60.4
F5	100.0	80.6	100.0
F6	53.3	44.4	35.4
F7	90.0	77.8	91.7
F8	86.7	58.3	72.9
F9	66.7	69.4	81.3
F10	83.3	55.6	75.0
F11	93.3	91.7	100.0
F12	100.0	100.0	100.0
F13	100.0	100.0	87.5
F14	70.0	55.6	45.8

Firms	IoD of KM practices		
	Methods	KM applications of IT	KM-enabling management actions
F31	96.7	83.3	100.0
F32	100.0	100.0	97.9
F33	40.0	33.3	27.1
F34	90.0	50.0	75.0
F35	83.3	30.6	29.2
F36	90.0	61.1	58.3
F37	50.0	55.6	56.3
F38	76.7	55.6	52.1
F39	36.7	41.7	43.8
F40	70.0	50.0	64.6
F41	100.0	97.2	93.8
F42	93.3	52.8	85.4
F43	53.3	61.1	58.3
F44	83.3	100.0	79.2

F15	76.7	50.0	39.6	F45	100.0	91.7	100.0
F16	100.0	58.3	50.0	F46	63.3	44.4	91.7
F17	66.7	58.3	85.4	F47	56.7	33.3	45.8
F18	100.0	58.3	89.6	F48	50.0	50.0	70.8
F19	53.3	91.7	93.8	F49	100.0	83.3	93.8
F20	30.0	36.1	27.1	F50	100.0	100.0	100.0
F21	46.7	38.9	31.3	F51	100.0	83.3	93.8
F22	86.7	72.2	39.6	F52	63.3	58.3	47.9
F23	100.0	52.8	45.8	F53	80.0	80.6	60.4
F24	100.0	94.4	93.8	F54	80.0	47.2	70.8
F25	90.0	88.9	87.5	F55	100.0	100.0	100.0
F26	53.3	44.4	43.8	F56	60.0	75.0	50.0
F27	40.0	30.6	39.6	F57	76.7	52.8	56.3
F28	100.0	83.3	62.5	F58	86.7	69.4	100.0
F29	100.0	100.0	100.0	F59	93.3	72.2	95.8
F30	100.0	100.0	91.7	F60	73.3	83.3	68.8

In order to see the relationship among the firms' level of adoption of practices in the three of the categories, a correlation analysis is carried out using the IoD, and the results are depicted in figure 16, 17 and 18. A positive and significant correlations (r = 0.66 between methods and KM-IT practices, r = 0.65 between methods and KM-enabling management actions, and r = 0.77 between KM-IT practices and supporting management actions) were detected among the three indices. These evidence that the higher the number of KM-methods adopted by the firm, there is likely that firms will adopt a greater number of KM-IT practices and KM-enabling management actions (and vice versa). Also, the same is true for the third correlation, relationship between the adoption of KM-IT applications and KM-enabling management actions. Thus, the comparisons between the three indices show that a firm that adopts many (few) practices from one of the categories will also introduce many (few) practices from the other two categories. This supports the fact that KM practices can be integrated and well

connected to one another if a company wants or can implement a group of practices. However, this does not indicate the relationship among the firms' intensity of use of practices in the categories which is the important part for the successful introduction and development of KM programs in firms. So, this part is discussed in the following section.

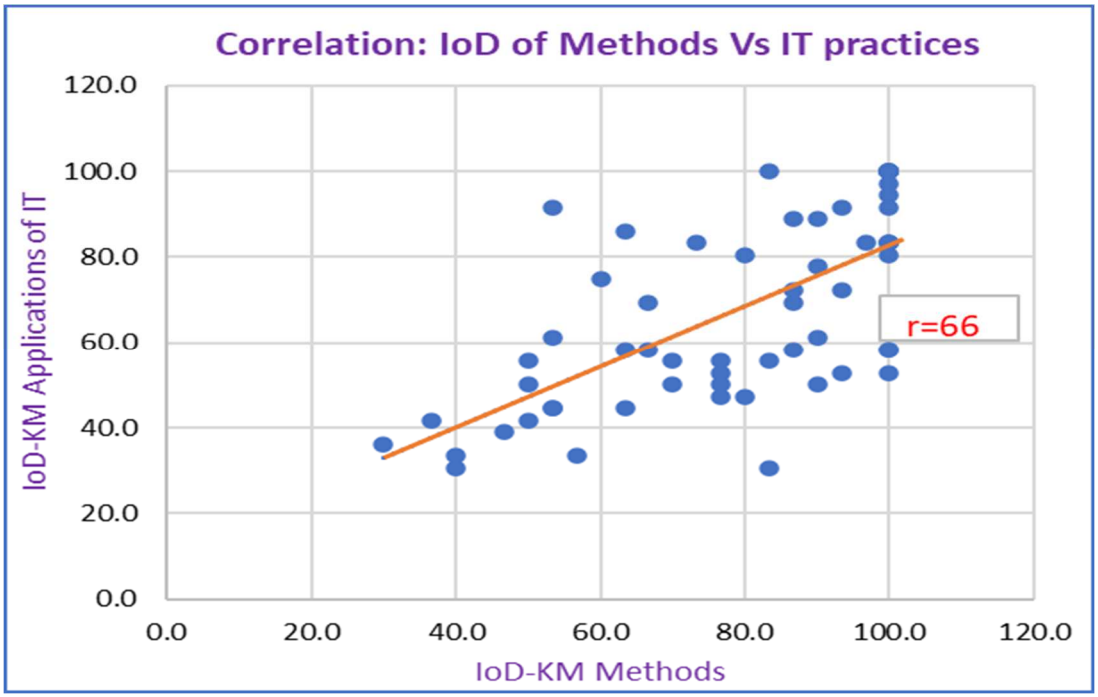


Figure 16. Correlation between firms' adoption of KM-Methods and KM applications of IT practices

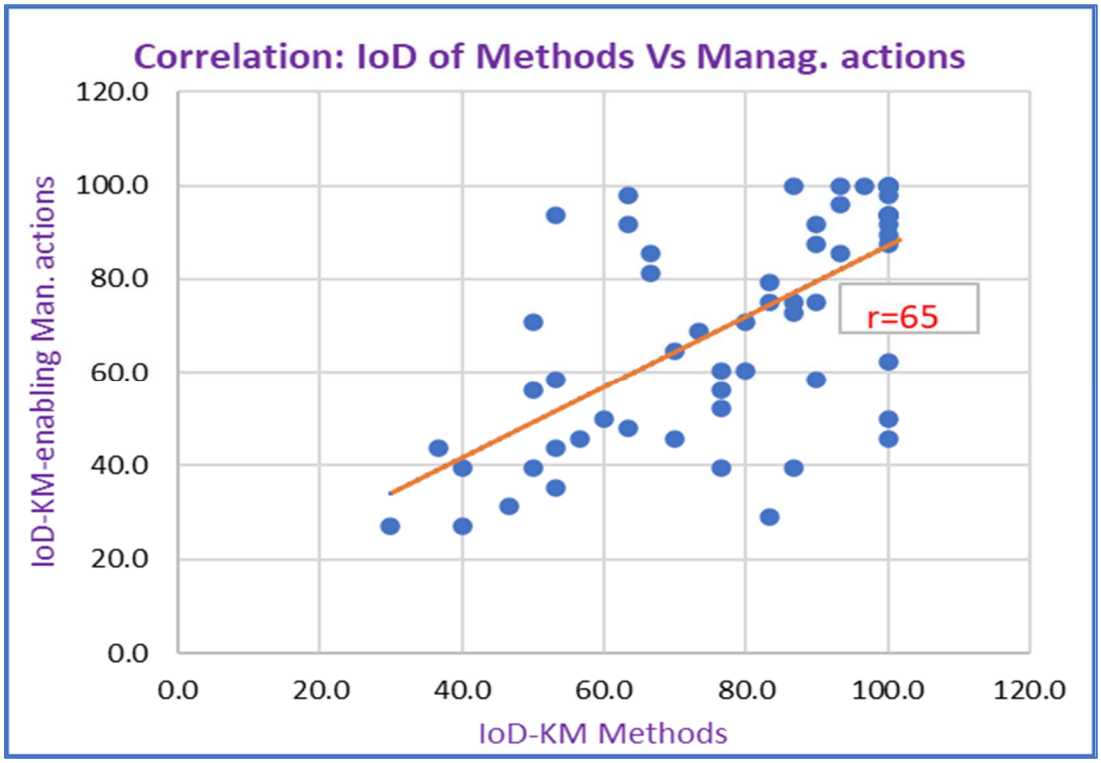


Figure 17. Correlation between firms' adoption of KM-Methods and KM-enabling management actions

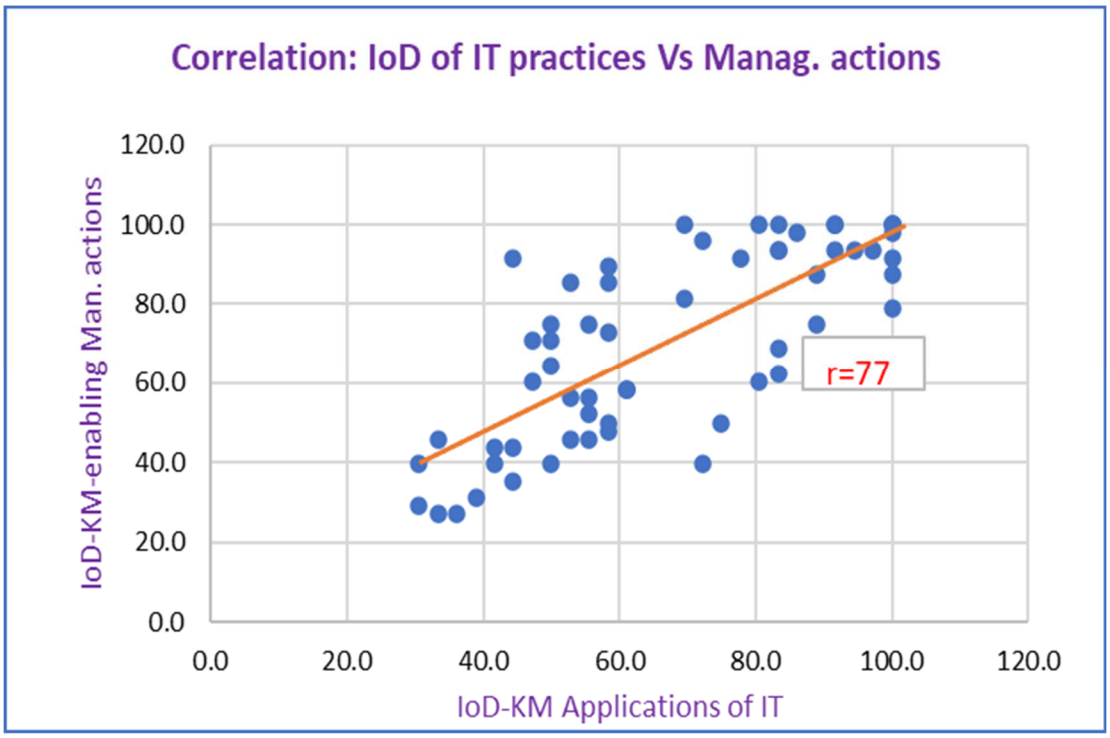


Figure 18. Correlation between firms' adoption of KM applications of IT and KM-enabling management actions.

5.4.2.2 Firms' intensity of use of KM practices and the relationship among categories of practices

Regarding the firms' level of use (IoUI) for each KM-categories, table 21 shows that it ranges from 12.5 for F20 (a firm that uses KM-methods but not regularly) to 91.7 for F51 (a firm that uses KM-methods intensely) with a mean of 45.2. Similarly, the intensity of use ranges from 11.1 (F33) to 91.7 (F44) with a mean of 41.1 for KM applications of IT practices, and 7.8 (F35) to 88 (F45) with a mean of 40.5 for KM-enabling management actions. In comparison to the three categories, the firms' IoUI (looking at the mean values) is found lowest with the practices in the third category, KM-enabling management actions. Even if there are some firms which have a better intensity of use of practices at each KM category, the firms' level of use of KM practices is, in general, low (on average below 45 IoUI) and far from the level of adoption (on average above 67 IoD as mentioned earlier in the previous section). Even in this case, there is a positive and significant correlations (r = 0.713 between methods and IT applications, r = 0.709 between methods and management actions, and r = 0.704 between IT applications and management actions) among the firms' level of use of practices in the three of the KM-categories (figure 19, 20 & 21).

Table 21. Firms' intensity of use of KM practices at each category

Firms	IoUI of KM practices		
	Methods	KM applications of IT	KM-enabling management actions
F1	38.3	55.6	43.2
F2	39.2	43.1	51.6
F3	40.0	17.4	26.0
F4	41.7	32.6	34.9
F5	79.2	63.2	78.1
F6	35.0	27.8	20.8
F7	41.7	51.4	50.0
F8	57.5	41.7	41.1
F9	28.3	34.0	48.4
F10	42.5	29.2	29.7
F11	54.2	72.2	78.6

Firms	IoUI of KM practices		
	Methods	KM applications of IT	KM-enabling management actions
F31	32.5	35.4	70.3
F32	86.7	75.0	65.1
F33	13.3	11.1	9.4
F34	51.7	25.0	37.5
F35	35.0	11.8	7.8
F36	32.5	35.4	19.3
F37	31.7	34.7	27.6
F38	32.5	23.6	18.8
F39	17.5	21.5	18.2
F40	57.5	40.3	41.7
F41	60.0	75.0	76.0

F12	76.7	80.6	73.4	F42	53.3	31.3	55.7
F13	60.0	67.4	44.3	F43	29.2	45.8	30.7
F14	21.7	22.2	16.7	F44	58.3	91.7	63.5
F15	40.8	25.7	14.1	F45	70.8	26.4	88.0
F16	45.0	18.8	24.5	F46	21.7	16.0	35.4
F17	44.2	45.1	71.9	F47	30.0	20.1	21.9
F18	49.2	33.3	42.2	F48	20.0	25.0	25.0
F19	20.0	45.8	57.3	F49	75.8	67.4	63.0
F20	12.5	13.9	8.9	F50	60.0	63.9	55.2
F21	22.5	15.3	10.9	F51	91.7	63.9	80.2
F22	51.7	41.7	18.2	F52	44.2	47.9	24.0
F23	56.7	29.2	21.9	F53	36.7	43.8	30.2
F24	74.2	66.7	66.7	F54	36.7	20.1	35.4
F25	62.5	52.8	53.1	F55	85.0	68.1	50.0
F26	26.7	24.3	23.4	F56	20.0	43.8	23.4
F27	25.0	15.3	19.3	F57	31.7	34.0	24.0
F28	37.5	47.9	25.0	F58	52.5	47.2	66.1
F29	71.7	74.3	56.8	F59	63.3	34.7	49.5
F30	55.0	61.8	38.0	F60	30.8	34.7	29.7

These correlations underline that the higher the firm's intensity of use of KM-methods, the higher the firm will intensely use KM-IT applications and KM-enabling management actions (and vice versa among the three categories). Thus, it can be summarized that the more firms intensely used practices found in one of the KM-category, the more likely firms will intensely use practices found in the other two KM-categories.

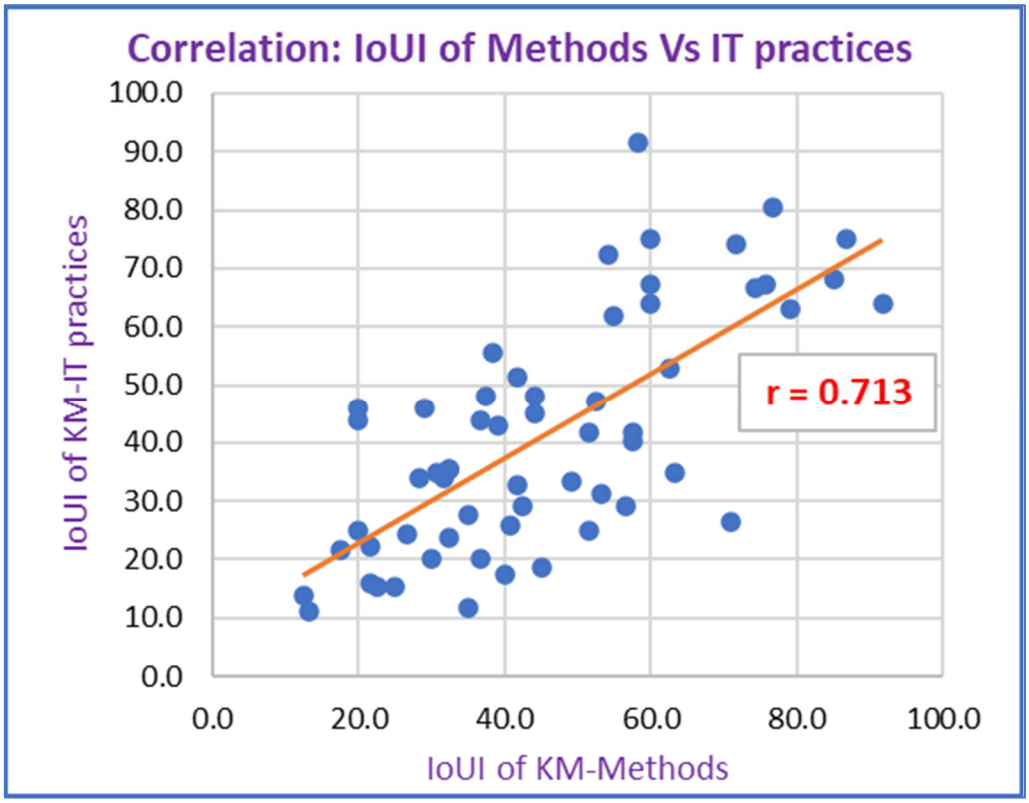


Figure 19. Correlation between firms' use of KM-Methods and KM applications of IT

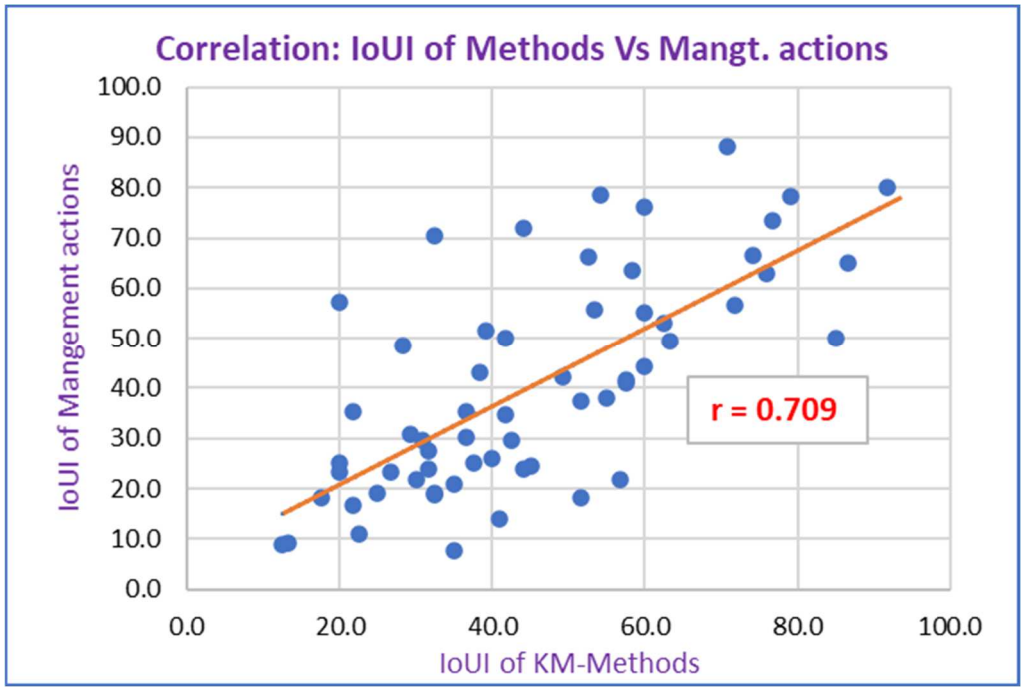


Figure 20. Correlation between firms' use of KM-Methods and KM-enabling management actions

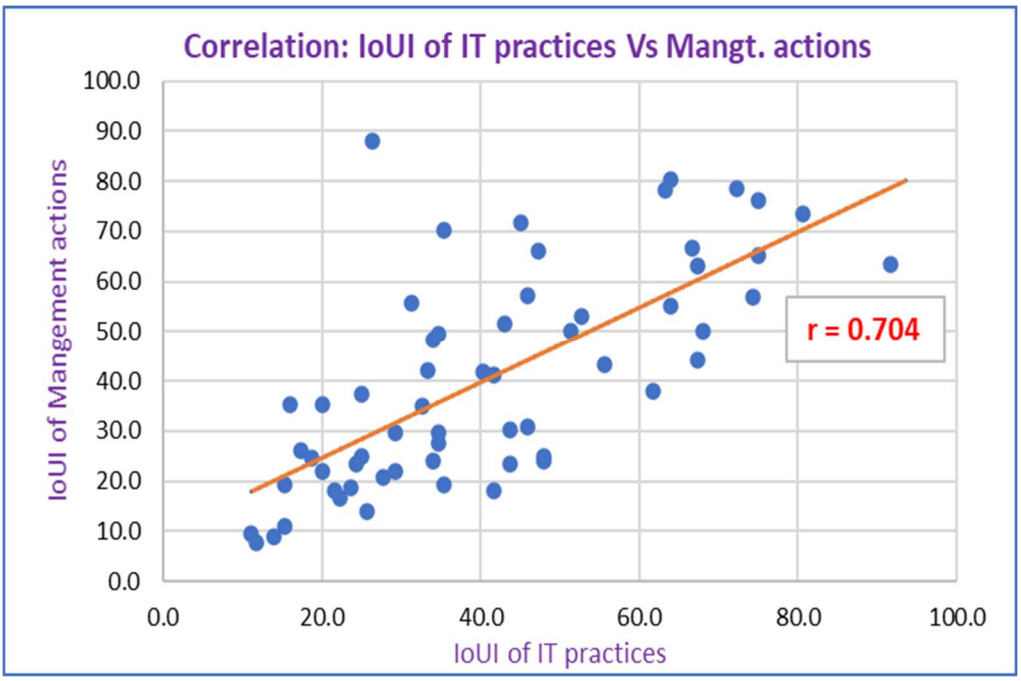


Figure 21. Correlation between firms' use of KM applications of IT and KM-enabling management actions

From both comparisons presented, i.e., with respect to the firms' index of differentiation and intensity of use index among the three KM categories, it can be summarised that the more firms adopt and intensely used practices found in one of the KM-category, the more likely firms will adopt and intensely use more practices found in the other two categories. This implies that practices are interrelated and supporting each other if firms use a group of them. For example, the more KM applications of IT practices are used by firms, they will facilitate the firms' use of practices related to both Methods and KM-enabling management actions, for instance, by creating an IT supported environment to effectively apply and use the other practices. Also, the more firms exercised practices related to KM-enabling management actions, since they are practices related to the overall managerial and organizational aspects of the company including the top management commitment, it supports firms to the effective utilization of practices found under both Methods and KM applications of IT categories. This clearly highlights and supports the literature that KM practices can be integrated and well connected to one another if a company wants or can do so as to get the benefit from implementing different or a group of practices that can include different approaches to manage knowledge, in line with a multi-dimensional view of KM (Dalkir, 2011; Edwards, 2015). To sum up, it can be noted that all the results of the analysis, either from the individual firms perspective (section 5.4.2) or individual practices (sections 5.1-5.3 and 5.4.1) points of view, and the adoption or intensity

of use of KM practices, support this literature, i.e., different KM practices can be integrated to one another and can help firms to manage their knowledge resources.

6. Conclusion

The main focus of this study was on KM practices used by companies not only to manage their own knowledge internally, but also to see their application to the case of interfirm relationships (in supply chains). The recent literature shows that there is an increasing interest in KM in inter-firm relationships, especially in the case of client-supplier relationships in SCs. Consequently, it is often argued that KM is an important element of companies' strategic programs not only internally but also to manage inter-firm knowledge exchange, exploit collaborative learning, and improve organizational and economic efficacy of joint projects in SCs. However, despite this growing interest in these issues, based on a systematic literature review this thesis illustrated that there is a lack of basic definitions and classifications especially on key notions that have both a conceptual and a practical importance, as in the case of the notion of KM practice, both when it is applied to the intra-firm and also (especially) in the case of SC inter-firm relationships. Moreover, there is insufficient empirical research on the level of adoption and diffusion, as well as the intensity of use of the various KM practices. Again, this is not only the case of KM in inter-firm collaborations, but also as regards the internal organizational context. Clarifying definitions and classifications of KM practices in intra- and inter-firm contexts is specifically important to make executives aware of the potential applications of KM, and to guide firms that need either to introduce new KM practices or develop their KM programs in their business activities, especially with reference to relationships with SCs.

Based on the above-mentioned gaps, the following three research questions (RQ) have been formulated and examined:

RQ1: What is or can be a knowledge management practice (i.e., what definition can be proposed)?

RQ2: Which KM practices are mainly used or proposed for application in companies (internally) and inter-firm relationships (in SCs), and how can be these practices categorized in a consistent way?

RQ3: To what extent (i.e., intensity of use) these KM practices are exercised by firms?

To answer for the first two research questions, a systematic survey of the recent scientific literature, based on a combination of a quantitative and a qualitative approach was conducted. The state-of-the art of research on KM-SC in general and particularly KM practices was

examined, and the most important concepts, definitions, and taxonomies that can be relevant especially for inter-firm relationships in SCs were identified and systematized. Based on the deep analysis of the literature., the researcher identifies the presence of lack of common definition and classification of KM practices and decided to provide a definition and classification (at least into a group of primary categories) of KM practice. Thus, a first attempt is made to provide a consistent definition of KM practices in business and, secondly, to categorize them by introducing a new triple-category classification that considers all the different typologies that should be included. The definition provided in this study is important that it clearly underlines as KM practices are activities explicitly targeted to manage knowledge as a resource, and not simply indirect or unconscious ways to handle knowledge. Also, its applicability to both the intrafirm and interfirm context (in the case of SCs, they explicitly refer to practices that can support KM in inter-firm collaboration) is another advantage. Thirdly, in further response to RQ2, based on a review of the existing studies and supported with inclusion of feedbacks from KM experts, a comprehensive list of KM practices was developed. The significance of this classification is that it has more or less a clear demarcation among the three proposed primary group of categories, and it includes the forgotten KM-enabling supporting managerial practices, in a comprehensive way. More substantially, it provides specific lists of practices in each category with a characterization of each KM practice, both in general terms and for its potential application to interfirm relationships in SC where previous classifications had not addressed it.

As for RQ3, a survey was carried out aimed at empirically assessing the level of adoption and use of KM practices in a sample of European large and medium sized manufacturing firms. A structured questionnaire, sent to executives, investigated which KM practices are adopted and measured their intensity of use. One of the important parts of this study is that, to understand how knowledge is managed differently in the internal organizational context compared to the external inter-firm environment (specifically with suppliers and customers), the survey investigated both aspects. Among the important findings, the study confirmed that all the proposed practices are known and, to some extent, adopted by the sample firms but with a very different adoption and intensity of use. It was also found that a lower intensity of use of KM practices regards the inter-firm level. Also, firms use less intensely those practices which are called “elective” in accordance with the KM literature. The results also helped to respond to RQ2 by adding information about the level of adoption and intensity of use of each practice in

the defined taxonomy, i.e., relative importance of each practice, which is really important for both research and practice.

Moreover, the correlation analyses depict two important findings. The first which is concerned to the relationships between the use of practices at firm and inter-firm level, showed that the more practices intensely used internally, the more likely firms will intensely practice them to manage their knowledge in relationship with suppliers and customers. It can be concluded here that the intensive use of practices at intra-firm level helps firms to extend the adoption and use of the practices to the inter-firm level which in turn is important for the KM in supply chains. The second finding is in relation to the correlation among the use of practices in the three of the categories of KM practices, and with this, the findings revealed that if a firm adopts or intensely used more practices in one of the KM categories, likely the greater number of practices will also be adopted and intensely used by this firm from the other two KM categories. This finding supports that KM practices can be integrated and well connected to one another if companies want, and it helps them to benefit from implementing different or a group of practices that can include different approaches to manage knowledge. Overall, this study adds to a better understanding of how knowledge should be managed in collaboration in SC interfirm relationships (particularly in client – supplier interfirm relationships) using KM practices for improving business performance.

6.1 Research and managerial implications

The study has both conceptual and practical important implications. As for the contribution to the research, the major implication of the results of this study is that they can represent a starting point of further investigations aimed to facilitate the inclusion of concepts and methods of KM into business education and, of course, also to the practice. Especially, there is a necessity to transform generic concepts and ideas, developed in KM research, into concrete definitions, so that can be more easily understood by future business students and managers. Again, this is important also to direct the future research on this issue. Studying KM practices is important but if there is no a common definition, that's a problem. The main argument here is that systematic defining and classifying KM practices may be more appropriate for a wide recognition and acceptance than fragmented and highly localized approaches. In particular, the paper contributes to the research on KM in SCs by making a step towards a systematic conceptualization of KM practices and by highlighting the gaps that may need to be filled in the future studies. With this regard, the study provides a consistent definition of KM practices and a triple-category classification which is supported with an initial empirical study. This

provides some conceptual clarity on KM practices in general and specifically its application to the case of inter-firm relationships within SCs. It also provides researchers a basis to test hypotheses about the relationships among the primary categories of KM practices, and firms output attributes (e.g., innovation performance) using real data that can be collected from firms. This can represent the starting point of a future research agenda.

As for the implications for practitioners, primarily, the classification and the comprehensive list of KM practices provided by this study can be used as an initial structured and synoptic reference useful for the design and implementation of KM courses for business managers and future business students. Particularly important is the characterization of the potential usefulness of the various KM practices for the adoption in an inter-firm relationship in SCs: indeed, as mentioned, competition more and more tends to involve entire SCs and networks of firms rather than single companies, so managers must learn organizational and managerial methods to manage knowledge resources and processes at the level of SCs.

Also, the current business environment makes it more and more evident that to face different challenging issues (including the COVID-19 impacts), companies need to take measures. In this aspect, it is important to know KM practices because they MAY be of help, but what practice and how this must be studied in the future. Of course, with the classification and this initial study, all this can be easier. Consequently, a capability to implement and effectively handle KM practices must become important in business education.

Another important practical implication is that the taxonomic scheme developed and attempted to test with an initial empirical validation provides managers and consultants a clear understanding of the possible KM practices that can be adopted internally as well as at inter-firm level for a better inter-firm relationships and SC performance, i.e., to facilitate creation, delivery, sharing, and protection of knowledge across SC partners (manufacturers, suppliers, customers, service providers, etc.) for achieving strategic goals. Furthermore, the findings from the additional results of the correlation analysis, on the relationship between the intensity of use of practices internally and at inter-firm level (the positive and high correlation) gave lesson to firms that the proper use of the practices for the internal KM also supports towards using the potential practices in collaboration with their suppliers and customers for a better collaborative management of knowledge resources. Finally, the findings of this study may be of great help for policymakers, in identifying the weaknesses of the firms and finding specific policies to support the effectiveness of the manufacturing sector by improving their management processes and the circulation of knowledge among competing firms.

6.2 Limitations and opportunities for future research

Apart from the important pictures drawn, as a first attempt to a triple-part conceptualization of KM practices and an initial empirical analysis on the level of use of the practices, this study has some limitations which can also be a starting point for a future research agenda.

First, the sample in this research is not representative due to the impact of COVID-19 pandemic where it was very hard to get direct contact with experts or collect enough survey responses from the companies at that very difficult time. As the sample is not representative and because of the different number of companies represented in each country, the study cannot make different comparisons, for example, based on the nations, which could be one of future research opportunity, and thus the results are valid on the range of the examined companies. Thus, further conceptual and empirical validation is required to assess the applicability and relevance of the proposed classification using a statistically representative sample of large firms for meaningful generalization of the results. Especially, as mentioned, it is essential to go in deeper details about the specific application of KM practices to SCs, because, as revealed by the analysis in this study, the current literature remains still at a too general level.

Second, concerning the focus of this study, KM in SC interfirm relationships, the study was paying attention to the analysis of KM practices used by firms only in relationship with their main suppliers and customers. This did not consider the full dyads and the supply networks, to look the application of the practices in the full SC management, which would require specifically designed studies.

Third, since the findings of this study evidenced that the general level of use of KM practices, specifically at the inter-firm level is low, another research direction ought to investigate the potential barriers hindering the successful implementation and intense use of the KM practices by firms in collaboration with their SC partners.

Finally, while the importance of inter-firm relationships along SCs has long been underlined (Albino et al., 1998; Cricelli & Grimaldi, 2010), it is also becoming more and more evident nowadays specially in contingent situations, like in the COVID-19 pandemics (Gregurec et al., 2021; Kumar et al., 2020). Even though this study was planned before the COVID-19 time, and the goal was not explicitly that of investigating this issue, as a future research direction, this study suggests discussing the new needs of supply chains in the context of the COVID-19 pandemics and the previsions for a post-Covid economy. In this framework, better

understanding and implementation of KM practices might also help, therefore, some insights might be welcomed.

References

Agostini, L., Nosella, A., Sarala, R., Spender, J. C., & Wegner, D. (2020). Tracing the evolution of the literature on knowledge management in inter-organizational contexts: a bibliometric analysis. *Journal of Knowledge Management*, *24*(2), 463–490. https://doi.org/10.1108/JKM-07-2019-0382

Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly*, 107–136.

Albino, V., Claudio Garavelli, A., & Schiuma, G. (1998). Knowledge transfer and inter-firm relationships in industrial districts: The role of the leader firm. *Technovation*, *19*(1), 53–63. https://doi.org/10.1016/S0166-4972(98)00078-9

Almuiet, M. Z., & Zawaideh, F. (2019). Intelligent agent framework for knowledge acquisition in supply chain management. *International Journal of Scientific and Technology Research*, *8*(9), 1984–1990.

Anand, A., Kant, R., Patel, D. P., & Singh, M. D. (2015). Knowledge Management Implementation: A Predictive Model Using an Analytical Hierarchical Process. *Journal of the Knowledge Economy*, *6*(1), 48–71. https://doi.org/10.1007/s13132-012-0110-y

Andreeva, T., & Kianto, A. (2012). Does knowledge management really matter? Linking knowledge management practices, competitiveness and economic performance. *Journal of Knowledge Management*, *16*(4), 617–636. https://doi.org/10.1108/13673271211246185

Attia, A. (2015). Testing the effect of marketing strategy alignment and triple-A supply chain on performance in Egypt. *EuroMed Journal of Business*, *10*(2), 163–180. https://doi.org/10.1108/EMJB-07-2014-0020

Attia, A., & Essam Eldin, I. (2018). Organizational learning, knowledge management capability and supply chain management practices in the Saudi food industry. *Journal of Knowledge Management*, *22*(6), 1217–1242. https://doi.org/10.1108/JKM-09-2017-0409

Attia, A., & Salama, I. (2018). Knowledge management capability and supply chain management practices in the Saudi food industry. *Business Process Management Journal*, *24*(2), 459–477. https://doi.org/10.1108/BPMJ-01-2017-0001

Azizi, R., Maleki, M., Moradi-Moghadam, M., & Cruz-Machado, V. (2016). The impact of knowledge management practices on supply chain quality management and competitive advantages. *Management and Production Engineering Review*, *7*(1), 4–12. https://doi.org/10.1515/mper-2016-0001

Batista, L., Dora, M., Toth, J., Molnár, A., Malekpoor, H., & Kumari, S. (2019). Knowledge management for food supply chain synergies–a maturity level analysis of SME companies. *Production Planning and Control*, *30*(10–12), 995–1004. https://doi.org/10.1080/09537287.2019.1582104

Bertoni, M., & Larsson, A. (2011). Engineering 2.0: An approach to support cross-functional teams in overcoming knowledge-sharing barriers in PSS design. *International Journal of Product Development*, *15*(1–3), 115–134. https://doi.org/10.1504/IJPD.2011.043664

Bhosale, V. A., & Kant, R. (2016). Metadata analysis of knowledge management in supply chain: Investigating the past and predicting the future. In *Business Process Management Journal* (Vol. 22, Issue 1, pp. 140–172). Emerald Group Publishing Ltd. https://doi.org/10.1108/BPMJ-02-2015-0014

Bolisani, E., & Bratianu, C. (2018). *Emergent knowledge strategies: Strategic thinking in*

knowledge management (Vol. 4). Springer.

Bolisani, E., Cazzaniga, F., Cegarra-Navarro, J. G., & Martinez-Martinez, A. (2017). Identification and Comparison of KM Strategic Approaches: Analysis of Spanish KIBS Companies. *18th European Conference on Knowledge Management (ECKM 2017). Academic Conferences and Publishing Limited*.

Bounfour, A. (2002). *The management of intangibles: The organisation's most valuable assets*. Routledge. https://doi.org/https://doi.org/10.4324/9780203465035

Bratianu, C., & Bolisani, E. (2015). Knowledge strategy: An integrated approach for managing uncertainty. In Massaro M, Garlatti A (Eds.). *Proceedings of the 16th European Conference on Knowledge Management, University of Udine, Italy, 3-4 September 2015*, 169–177.

Butt, A. S., Shah, S. H. H., & Ahmad, A. B. (2021). Does knowledge hiding undermine buyer-supplier relationship performance in supply chains? A dyadic perspective. *VINE Journal of Information and Knowledge Management Systems*. https://doi.org/10.1108/VJIKMS-06-2020-0118

Cai, S., Goh, M., De Souza, R., & Li, G. (2013). Knowledge sharing in collaborative supply chains: Twin effects of trust and power. *International Journal of Production Research*, *51*(7), 2060–2076. https://doi.org/10.1080/00207543.2012.701780

Centobelli, P., Cerchione, R., & Esposito, E. (2017). Knowledge management systems: The hallmark of SMEs. *Knowledge Management Research and Practice*, *15*(2), 294–304. https://doi.org/10.1057/s41275-017-0054-x

Centobelli, P., Cerchione, R., & Esposito, E. (2019). Measuring the use of knowledge management systems in supply firms. *Measuring Business Excellence*, *23*(4), 426–441. https://doi.org/10.1108/MBE-12-2018-0107

Cerchione, R., & Esposito, E. (2016). A systematic review of supply chain knowledge management research: State of the art and research opportunities. *International Journal of Production Economics*, *182*, 276–292. https://doi.org/10.1016/j.ijpe.2016.09.006

Cerchione, R., & Esposito, E. (2017). Using knowledge management systems: A taxonomy of SME strategies. *International Journal of Information Management*, *37*(1), 1551–1562. https://doi.org/10.1016/j.ijinfomgt.2016.10.007

Cerchione, R., Esposito, E., & Spadaro, M. R. (2015). The spread of knowledge management in SMEs: A scenario in evolution. *Sustainability (Switzerland)*, *7*(8), 10210–10232. https://doi.org/10.3390/su70810210

Charterina, J., Landeta, J., & Basterretxea, I. (2018). Mediation effects of trust and contracts on knowledge-sharing and product innovation: Evidence from the European machine tool industry. *European Journal of Innovation Management*, *21*(2), 274–293. https://doi.org/10.1108/EJIM-03-2017-0030

Chen, Le, & Fong, P. S. W. (2015). Evaluation of knowledge management performance: An organic approach. *Information and Management*, *52*(4), 431–453. https://doi.org/10.1016/j.im.2015.01.005

Chen, Liang, Ellis, S., & Holsapple, C. (2018). A knowledge management perspective of supplier development: Evidence from supply chain scholars and consultants. *Knowledge and Process Management*, *25*(4), 247–257. https://doi.org/10.1002/kpm.1566

Choi, B., & Jong, A. M. (2010). Assessing the impact of knowledge management strategies announcements on the market value of firms. *Information and Management*, *47*(1), 42–52. https://doi.org/10.1016/j.im.2009.10.001

Commission, E. (2005). *The new SME definition: User guide and model declaration*. Office

for Official Publications of the European Communities.

Cricelli, L., & Grimaldi, M. (2010). Knowledge-based inter-organizational collaborations. *Journal of Knowledge Management*, *14*(3), 348–358. https://doi.org/10.1108/13673271011050094

Dalkir, K. (2011). Knowledge management in theory and practice. In *Knowledge Management in Theory and Practice* (Second). MIT Press. https://doi.org/10.4324/9780080547367

Durst, S., & Evangelista, P. (2018). Logistics knowledge management: state of the art and future perspectives. *Knowledge Management Research and Practice*, *16*(4), 427–434. https://doi.org/10.1080/14778238.2018.1525038

Edwards, J. S. (2015). Knowledge Management Concepts and Models. In E. Bolisani & M. Handzic (Eds.), *Advances in Knowledge Management: Celebrating Twenty Years of Research and Practice* (pp. 25–44). Springer International Publishing. https://doi.org/10.1007/978-3-319-09501-1_2

Flynn, B. B., Kakibara, S. S., Schroeder, R. G., Bates, K. A., & Flynn, E. J. (1990). *Empirical Research Methods in Operations Management*. *9*(2).

Frohlich, M. T. (2002). Techniques for improving response rates in OM survey research. *Journal of Operations Management*, *20*(1), 53–62. https://doi.org/10.1016/S0272-6963(02)00003-7

Garrido-Moreno, A., Lockett, N., & García-Morales, V. (2014). Paving the way for CRM success: The mediating role of knowledge management and organizational commitment. *Information and Management*, *51*(8), 1031–1042. https://doi.org/10.1016/j.im.2014.06.006

Goodman, L. A. (1961). Snowball sampling. *The Annals of Mathematical Statistics*, *32*(1), 148–170.

Grant, R. M. (1996). Towards a knowledge-based theory of the firm. *Strategic Management Journals*, *17*, 109–122.

Grant, S. B., & Preston, T. A. (2019). Using social power and influence to mobilise the supply chain into knowledge sharing: A case in insurance. *Information and Management*, *56*(5), 625–639. https://doi.org/10.1016/j.im.2018.10.004

Greenhalgh, T. (1997). How to read a paper: Papers that summarise other papers (systematic reviews and meta-analyses). *BMJ*, *315*(7109), 672 LP – 675. https://doi.org/10.1136/bmj.315.7109.672

Gregurec, I., Tomičić Furjan, M., & Tomičić-pupek, K. (2021). The impact of covid-19 on sustainable business models in SMEs. *Sustainability (Switzerland)*, *13*(3), 1–24.

He, Q., Gallear, D., Ghobadian, A., & Ramanathan, R. (2019). Managing knowledge in supply chains: a catalyst to triple bottom line sustainability. *Production Planning and Control*, *30*(5–6), 448–463. https://doi.org/10.1080/09537287.2018.1501814

Heisig, P. (2009). Harmonisation of knowledge management – comparing 160 KM frameworks around the globe. *Journal of Knowledge Management*, *13*(4), 4–31. https://doi.org/10.1108/13673270910971798

Holsapple, C. W., & Singh, M. (2003). The knowledge chain model: activities for competitiveness. In H. C.W. (Ed.), *Handbook on knowledge management. International Handbooks on Information Systems* (pp. 215–251). Springer. https://doi.org/https://doi.org/10.1007/978-3-540-24748-7_11

Hult, G. T. M., Ketchen, D. J., Cavusgil, S. T., & Calantone, R. J. (2006). Knowledge as a strategic resource in supply chains. *Journal of Operations Management*, *24*(5), 458–475. https://doi.org/10.1016/j.jom.2005.11.009

Hult, G. T. M., Slater, S. F., & Ketchen, D. J. (2004). Information Processing , Knowledge Development , and Strategic Supply Chain Performance Author (s): G . Tomas M . Hult , David J . Ketchen Jr . and Stanley F . Slater Published by : Academy of Management Stable URL : http://www.jstor.org/stable/20159575. *The Academy of Management Journal*, *47*(2), 241–253.

Ichijo, K. (2007). The strategic management of knowledge. In K. Ichijo & N. Ikujiro (Eds.), *Knowledge creation and management. New challenges for managers*. Oxford University Press, Oxford.

Inkinen, H. (2016). Review of empirical research on knowledge management practices and firm performance. *Journal of Knowledge Management*, *20*(2), 230–257. https://doi.org/10.1108/JKM-09-2015-0336

Inkinen, H., Kianto, A., Vanhala, M., & Ritala, P. (2017). Assessing the universality of knowledge management practices. *Journal of Knowledge Management*, *21*(6). https://doi.org/10.1108/JKM-09-2016-0394

Inkinen, H. T., Kianto, A., & Vanhala, M. (2015). Knowledge management practices and innovation performance in Finland. *Baltic Journal of Management*, *10*(4), 432–455. https://doi.org/10.1108/BJM-10-2014-0178

Jafari, M., Akhavan, P., Fesharaki, M. N., & Fathian, M. (2007). Iran aerospace industries' KM approach based on a comparative study: A benchmarking on successful practices. *Aircraft Engineering and Aerospace Technology*, *79*(1), 69–78. https://doi.org/10.1108/00022660710720511

Jean, R. J. B., Sinkovics, R. R., & Hiebaum, T. P. (2014). The effects of supplier involvement and knowledge protection on product innovation in customer-supplier relationships: A study of global automotive suppliers in China. *Journal of Product Innovation Management*, *31*(1), 98–113. https://doi.org/10.1111/jpim.12082

Khyzer Bin Dost, M., Rehman, C. A., Gilaninia, S., Ismail, K. B., & Wasim Akram, M. (2018). The impact of knowledge management's practices on supply chain performance of the dairy sector in Central Punjab: a mediating role of decentralization. *Economic Research-Ekonomska Istrazivanja* , *31*(1), 290–312. https://doi.org/10.1080/1331677X.2018.1426478

Kianto, A., & Andreeva, T. (2014). Knowledge Management Practices and Results in Service-Oriented versus Product-Oriented Companies. *Knowledge and Process Management*, *21*(4), 221–230. https://doi.org/10.1002/kpm.1443

Kovács, G., & Spens, K. (2010). Knowledge sharing in relief supply chains. *International Journal of Networking and Virtual Organisations*, *7*(2–3), 222–239. https://doi.org/10.1504/ijnvo.2010.031219

Kumar, A., Luthra, S., Mangla, S. K., & Kazançoğlu, Y. (2020). COVID-19 impact on sustainable production and operations management. *Sustainable Operations and Computers*, *1*(July), 1–7. https://doi.org/10.1016/j.susoc.2020.06.001

Lee, C. L., Ho, C. T., & Chiu, Y. L. (2008). The impact of knowledge management enablers on non-financial performance in small and medium enterprises. *International Journal of Technology Management*, *43*(1–3), 266–283. https://doi.org/10.1504/IJTM.2008.019419

Lefika, P. T., & Mearns, M. A. (2015). Adding knowledge cafés to the repertoire of knowledge sharing techniques. *International Journal of Information Management*, *35*(1), 26–32. https://doi.org/10.1016/j.ijinfomgt.2014.09.005

Li, Q., & Kang, Y. (2019). Knowledge sharing willingness and leakage risk: An evolutional game model. *Sustainability (Switzerland)*, *11*(3). https://doi.org/10.3390/su11030596

Li, S., Ragu-Nathan, B., Ragu-Nathan, T. S., & Subba Rao, S. (2006). The impact of supply chain management practices on competitive advantage and organizational performance. *Omega*, *34*(2), 107–124. https://doi.org/10.1016/j.omega.2004.08.002

Li, Y., Tarafdar, M., & Rao, S. S. (2012). Collaborative knowledge management practices: Theoretical development and empirical analysis. *International Journal of Operations and Production Management*, *32*(4), 398–422. https://doi.org/10.1108/01443571211223077

Liao, S. H., Chen, C. M., & Wu, C. H. (2008). Mining customer knowledge for product line and brand extension in retailing. *Expert Systems with Applications*, *34*(3), 1763–1776. https://doi.org/10.1016/j.eswa.2007.01.036

Lin, C., Hung, H. C., Wu, J. Y., & Lin, B. (2002). A knowledge management architecture in collaborative supply chain. *Journal of Computer Information Systems*, *42*(5 SPEC. ISS.), 83–94. https://doi.org/10.1080/08874417.2002.11647612

Liu, Z., Shang, J., & Lai, M. (2015). Incentive mechanism for knowledge sharing in E-commerce service supply chain: Complementarity, integration and risk attitude. *Journal of Electronic Commerce Research*, *16*(3), 175–193.

Mardani, A., Nikoosokhan, S., Moradi, M., & Doustar, M. (2018). The Relationship Between Knowledge Management and Innovation Performance. *Journal of High Technology Management Research*, *29*(1), 12–26. https://doi.org/10.1016/j.hitech.2018.04.002

Marra, M., Ho, W., & Edwards, J. S. (2012). Supply chain knowledge management: A literature review. *Expert Systems with Applications*, *39*(5), 6103–6110. https://doi.org/10.1016/j.eswa.2011.11.035

Martins, V. W. B., Rampasso, I. S., Anholon, R., Quelhas, O. L. G., & Leal Filho, W. (2019). Knowledge management in the context of sustainability: Literature review and opportunities for future research. *Journal of Cleaner Production*, *229*, 489–500. https://doi.org/10.1016/j.jclepro.2019.04.354

Mclaughlin, S. (2009). Improving Supply Chain Performance through the Implementation of Process Related Knowledge Transfer Mechanisms. *International Journal of Knowledge Management (IJKM)*, *5*(2), 64–86. https://doi.org/10.4018/jkm.2009040105

Navarro, J. G. C., Dewhurst, F. W., & Eldridge, S. (2010). Linking chief knowledge officers with customer capital through knowledge management practices in the Spanish construction industry. *International Journal of Human Resource Management*, *21*(3), 389–404. https://doi.org/10.1080/09585190903546946

Nguyen, H., & Harrison, N. (2019). Leveraging customer knowledge to enhance process innovation: Moderating effects from market dynamics. *Business Process Management Journal*, *25*(2), 307–322. https://doi.org/10.1108/BPMJ-03-2017-0076

Nikabadi, M. S. (2014). A framework for technology-based factors for knowledge management in supply chain of auto industry. *Vine*, *44*(3), 375–393. https://doi.org/10.1108/VINE-09-2013-0057

Nonaka, I., & Lewin, A. Y. (1994). A Dynamic Theory of Organizational Knowledge Creation Dynamic Theory Knowledge of Organizational Creation. *International Journal of Technology Management*, *August 2015*.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation* (Vol. 105). OUP USA.

Norman, P. M. (2004). Knowledge acquisition, knowledge loss, and satisfaction in high technology alliances. *Journal of Business Research*, *57*(6), 610–619. https://doi.org/10.1016/S0148-2963(02)00395-8

Patil, S. K., & Kant, R. (2013). A fuzzy DEMATEL method to identify critical success factors

of knowledge management adoption in supply chain. *Journal of Information and Knowledge Management*, *12*(3). https://doi.org/10.1142/S0219649213500196

Patil, S. K., & Kant, R. (2014a). A fuzzy AHP-TOPSIS framework for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers. *Expert Systems with Applications*, *41*(2), 679–693. https://doi.org/10.1016/j.eswa.2013.07.093

Patil, S. K., & Kant, R. (2014b). Ranking the barriers of knowledge management adoption in supply chain using fuzzy AHP method. *International Journal of Business Innovation and Research*, *8*(1), 52–75. https://doi.org/10.1504/IJBIR.2014.058047

Patil, S. K., & Kant, R. (2016). A fuzzy ANP-based approach for selection of knowledge management strategies to build resilient supply chain: An empirical case study. *International Journal of Integrated Supply Management*, *10*(2), 173–205. https://doi.org/10.1504/IJISM.2016.077074

Pérez-Salazar, M. del R., Aguilar-Lasserre, A. A., Cedillo-Campos, M. G., Juárez-Martínez, U., & Posada-Gómez, R. (2019). Processes and measurement of knowledge management in supply chains: an integrative systematic literature review. *International Journal of Production Research*, *57*(7), 2136–2159. https://doi.org/10.1080/00207543.2018.1521530

Phengchan, P., & Thangpreecharparnich, P. (2018). Advantages of knowledge management and supply chain integration. A case study of Thai palm oil production. *Management and Production Engineering Review*, *9*(4), 150–160. https://doi.org/10.24425/119555

Pinto, C. A. S. (2020). Knowledge management as a support for supply chain logistics planning in pandemic cases. *Brazilian Journal of Operations & Production Management*, *17*(3), 1–11. https://doi.org/10.14488/bjopm.2020.033

Raisinghani, M. S., & Meade, L. L. (2005). Strategic decisions in supply-chain intelligence using knowledge management: An analytic-network-process framework. *Supply Chain Management*, *10*(2), 114–121. https://doi.org/10.1108/13598540510589188

Riege, A. (2007). Actions to overcome knowledge transfer barriers in MNCs. *Journal of Knowledge Management*, *11*(1), 48–67. https://doi.org/10.1108/13673270710728231

Rodríguez-Enríquez, Cristian A., Alor-Hernández, G., Mejia-Miranda, J., Sánchez-Cervantes, J. L., Rodríguez-Mazahua, L., & Sánchez-Ramírez, C. (2016). Supply chain knowledge management supported by a simple knowledge organization system. *Electronic Commerce Research and Applications*, *19*, 1–18. https://doi.org/10.1016/j.elerap.2016.06.004

Rodríguez-Enríquez, Cristian Aarón, Alor-Hernández, G., Sánchez-Ramírez, C., & Córtes-Robles, G. (2015). Supply chain knowledge management: A linked data-based approach using SKOS. *Dyna*, *82*(194), 27–35. https://doi.org/10.15446/dyna.v82n194.54463

Ruel, S., Shaaban, S., & Ducros, M. (2019). Supply chain vulnerability: contributions from an edifying case study. *Journal of Enterprise Information Management*, *32*(2), 214–232. https://doi.org/10.1108/JEIM-05-2018-0086

Samuel, K. E., Goury, M. L., Gunasekaran, A., & Spalanzani, A. (2011). Knowledge management in supply chain: An empirical study from France. *Journal of Strategic Information Systems*, *20*(3), 283–306. https://doi.org/10.1016/j.jsis.2010.11.001

Schniederjans, D. G., Curado, C., & Khalajhedayati, M. (2020). Supply chain digitisation trends: An integration of knowledge management. *International Journal of Production Economics*, *220*(July 2019), 107439. https://doi.org/10.1016/j.ijpe.2019.07.012

Schoenherr, T., Griffith, D. A., & Chandra, A. (2014). Knowledge management in supply chains: The role of explicit and tacit knowledge. *Journal of Business Logistics*, *35*(2),

121–135. https://doi.org/10.1111/jbl.12042

Scholten, K., Sharkey Scott, P., & Fynes, B. (2019). Building routines for non-routine events: supply chain resilience learning mechanisms and their antecedents. *Supply Chain Management*, *24*(3), 430–442. https://doi.org/10.1108/SCM-05-2018-0186

Shakerian, H., Dehnavi, H. D., & Shateri, F. (2016). A Framework for the Implementation of Knowledge Management in Supply Chain Management. *Procedia - Social and Behavioral Sciences*, *230*(May), 176–183. https://doi.org/10.1016/j.sbspro.2016.09.022

Sher, P. J., & Lee, V. C. (2004). Information technology as a facilitator for enhancing dynamic capabilities through knowledge management. *Information and Management*, *41*(8), 933–945. https://doi.org/10.1016/j.im.2003.06.004

Shih, S. C., Hsu, S. H. Y., Zhu, Z., & Balasubramanian, S. K. (2012). Knowledge sharing-A key role in the downstream supply chain. *Information and Management*, *49*(2), 70–80. https://doi.org/10.1016/j.im.2012.01.001

Stevenson, M., & Spring, M. (2009). Supply chain flexibility: An inter-firm empirical study. *International Journal of Operations and Production Management*, *29*(9), 946–971. https://doi.org/10.1108/01443570910986238

Swan, J., Scarbrough, H., & Preston, J. (1999). Knowledge management-the next fad to forget people? *Proceedings of the 7th European Conference on Information Systems*, *June*, 668–678. http://is2.lse.ac.uk/asp/aspecis/19990007.pdf

Szuster, M., & Szymczak, M. (2016). Innovation, knowledge and information management in supply chains. *Engineering Management in Production and Services*, *8*(1), 26–36. https://doi.org/10.1515/emj-2016-0003

Taher, M. A., Bandarian, R., & Moghadam, M. R. S. (2017). Surveying the effects of CKMP of strategic managers on supply chain performance in Iran oil industry. *International Journal of Business Performance and Supply Chain Modelling*, *9*(1), 28–41. https://doi.org/10.1504/IJBPSCM.2017.083885

Tesavrita, C., Suryadi, K., Wiratmadja, I. I., & Govindaraju, R. (2017). Intra-organizational and inter-organizational knowledge sharing in collaborative learning process: A conceptual framework for SME. *2017 4th International Conference on Industrial Engineering and Applications, ICIEA 2017*, 187–191. https://doi.org/10.1109/IEA.2017.7939204

Thomas, A., Dorrington, P., Costa, F., Loudon, G., Francis, M., & Fisher, R. (2017). Organisational learning capability in SMEs: An empirical development of innovation in the supply chain. *Cogent Business and Management*, *4*(1), 1–20. https://doi.org/10.1080/23311975.2017.1364057

Tseng, S. M. (2014). The impact of knowledge management capabilities and supplier relationship management on corporate performance. *International Journal of Production Economics*, *154*, 39–47. https://doi.org/10.1016/j.ijpe.2014.04.009

Tubis, A. A., & Werbińska-Wojciechowska, S. (2021). Risk management maturity model for logistic processes. *Sustainability (Switzerland)*, *13*(2), 1–19. https://doi.org/10.3390/su13020659

Van Wijk, R., Jansen, J. J. P., & Lyles, M. A. (2008). Inter- and intra-organizational knowledge transfer: A meta-analytic review and assessment of its antecedents and consequences. *Journal of Management Studies*, *45*(4), 830–853. https://doi.org/10.1111/j.1467-6486.2008.00771.x

Venkatraman, S., & Venkatraman, R. (2018). Communities of Practice Approach for Knowledge Management Systems. *Systems*, *6*(4), 36.

https://doi.org/10.3390/systems6040036

Wadhwa, S., & Saxena, A. (2005). Knowledge management based supply chain: an evolution perspective. *Global Journal of E-Business and Knowledge Management*, *2*(2), 13–29.

Wang, C., Fergusson, C., Perry, D., & Antony, J. (2008). A conceptual case-based model for knowledge sharing among supply chain members. *Business Process Management Journal*, *14*(2), 147–165. https://doi.org/10.1108/14637150810864907

Wang, K. Q., Liu, H. C., Liu, L., & Huang, J. (2017). Green supplier evaluation and selection using cloud model theory and the QUALIFLEX method. *Sustainability (Switzerland)*, *9*(5), 1–17. https://doi.org/10.3390/su9050688

Ward, S., & Wooler, I. (2010). Keeping knowledge flowing in a downturn: Actions for knowledge and information managers. *Business Information Review*, *27*(4), 253–262. https://doi.org/10.1177/0266382110391633

Wernick, I. (2002). Environmental knowledge management. *Journal of Industrial Ecology*, *6*(2), 7–9. https://doi.org/10.1162/108819802763471735

Whitehead, K., Zacharia, Z., & Prater, E. (2019). Investigating the role of knowledge transfer in supply chain collaboration. *International Journal of Logistics Management*, *30*(1), 284–302. https://doi.org/10.1108/IJLM-07-2017-0184

Wiig, K. M. (1993). *Knowledge Management Foundations: Thinking about Thinking-how People and Organizations Represent, Create, and Use Knowledge*. Schema Press, Limited.

Wood, G., Dibben, P., & Meira, J. (2016). Knowledge transfer within strategic partnerships: the case of HRM in the Brazilian motor industry supply chain. *International Journal of Human Resource Management*, *27*(20), 2398–2414. https://doi.org/10.1080/09585192.2016.1221841

Xavier, A. F., Naveiro, R. M., Aoussat, A., & Reyes, T. (2017). Systematic literature review of eco-innovation models: Opportunities and recommendations for future research. *Journal of Cleaner Production*, *149*, 1278–1302. https://doi.org/10.1016/j.jclepro.2017.02.145

Yang, C. C., Marlow, P. B., & Lu, C. S. (2009). Knowledge management enablers in liner shipping. *Transportation Research Part E: Logistics and Transportation Review*, *45*(6), 893–903. https://doi.org/10.1016/j.tre.2009.05.003

Zerbino, P., Aloini, D., Dulmin, R., & Mininno, V. (2018). Knowledge Management in PCS-enabled ports: an assessment of the barriers. *Knowledge Management Research and Practice*, *16*(4), 435–450. https://doi.org/10.1080/14778238.2018.1473830

Zhao, J., de Pablos, P. O., & Qi, Z. (2012). Enterprise knowledge management model based on China's practice and case study. *Computers in Human Behavior*, *28*(2), 324–330.

Zimon, D., Tyan, J., & Sroufe, R. (2019). Implementing sustainable supply chain management: Reactive, cooperative, and dynamic models. *Sustainability (Switzerland)*, *11*(24). https://doi.org/10.3390/SU11247227

Appendix A: Questionnaire items

I) DIRECT PRACTICES (METHODS) OF KNOWLEDGE MANAGEMENT

Consider the following list of practices regarding the use of **methods** to manage knowledge internally (within the organization) and/or in the relation with suppliers and customers. Please rate your degree of use (0= *''we don't use it at all''*, *1= ''rarely used''*, *2= ''occasionally used''*, *3= ''frequently used''* and *4= ''used very frequently''*)

Item/practice	Level of usage (0-4)		
	Internally	**With suppliers**	**With customers**
Systematic collection of **lessons learnt** from past experience and produces reports or notes to re-use them			
Use of interactive collaborative methods to facilitate collective creation and sharing of knowledge in groups on specific issues/projects (e.g., **Knowledge Cafes** and similar approaches)			
Use of "**Peer to peer assistance**" to create and exchange knowledge between operators or professionals			
Use of groups/ networks of practitioners who share knowledge and help each other in their business/tasks on an ongoing basis (e.g., **Community of practices** and similar approaches)			
Mapping of available knowledge (using **knowledge domain mapping)** as an analysis and learning technique			
Systematic analysis of corporate social platforms and portals (Enterprise Social Network) and use as input for decisions (**Enterprise social network analysis**)			
Use of systematic methods for knowledge capture/retention (such as **mentoring, interviewing, coaching** etc.)			
Use of systematic problem-solving approaches, recovering past "cases, episodes or projects" and adapting them to the new situation (**Case Base reasoning** and similar approaches)			
Use of techniques, like **brainstorming,** to stimulate collective creativity			
Systematic search for information and knowledge on various platforms and online deposits (**online knowledge searches**)			

II) USE OF KNOWLEDGE MANAGEMENT APPLICATIONS OF IT TECHNOLOGIES

Consider the following list of practices regarding the use of **IT-based KM technologies** to manage knowledge internally and/or in the relation with suppliers and customers. Please rate your degree of use (0= *''we don't use it at all"*, *1= ''rarely used''*, *2= ''occasionally used''*, *3= ''frequently used''* and *4= ''used very frequently"*)

Item/practice	Level of usage (0-4)		
	Internally	**With suppliers**	**With customers**
Use of **Email and voice mail** to exchange and transfer knowledge			
Application of **chat rooms, forums, electronic bulletin boards** and similar tools for knowledge transfer			
Use of **Wiki** pages and similar sites created collectively to transfer/share knowledge and improve learning			
Use of **video conferencing technologies** or platforms (e.g., for remote meetings) to share knowledge			
Use of **database systems and shared folders** for knowledge storage, retrieval, and sharing			
Use of **Enterprise Resource Planning (ERP) systems** as a tool to share and exchange highly structured knowledge			
Use of "**Simple knowledge organization system (SKOS)**" and similar web-based platforms for e-procurement and automatic process of knowledge exchange in the supply chain			
Use of **Enterprise social media platforms** for knowledge acquisition and sharing (e.g., Yammer and similar enterprise social network platforms)			
Use of **cloud computing** technologies and related applications to store and retrieve knowledge			
Use of **Customer Relationship management (CRM)** systems for the acquisition, creation and sharing of knowledge			
Use of **Supplier Relationship Management (SRM)** systems for the creation and joint sharing of knowledge			
Use of **Artificial Intelligence** tools (e.g., data mining, machine learning, intelligent agents, etc.) for the automatic analysis of knowledge			

III) GENERIC MANAGERIAL PRACTICES THAT MAY ALSO SUPPORT KNOWLEDGE MANAGEMENT

Indicate the degree of use of the following KM-enabling **managerial practices** in relation to knowledge management internally and / or with suppliers and customers. (Degree of use: *0= ''we don't use it at all", 1= ''rarely used'', 2= ''occasionally used'', 3= ''frequently used'' and 4= ''used very frequently"*).

Item/practice	**Level of usage (0-4)**		
	Internally	**With suppliers**	**With customers**
Use of **project teams** (possibly inter-company) to facilitate the creation and sharing of knowledge among participants			
Adoption of explicit and deliberate **strategic plans** for knowledge management internally and / or with external partners			
Use of **training** programs (possibly with the participation of external partners) where participants can exchange and create knowledge			
Our company places great and deliberate emphasis on management actions and **collaborative KM**/knowledge exchange between employees and with external partners in the supply chain			
In our company, there is great **support from top management** in knowledge management programs and activities			
Our company has adopted an organic **structure for open knowledge sharing**			
In our company, there are managers dedicated to **knowledge management** with a precise mission and regular **assessments**			
Our company supports the creation and use of informal **networks for sharing knowledge** (internally and / or externally)			
Our company favours the creation of a climate of **trust** as a basis for sharing knowledge			
Use of **knowledge protection** techniques to reduce the risk of unauthorized disclosure and at the same time facilitate sharing between those who are authorized			
The company ensures the accurate and timely distribution/**communication** of acquired/new **knowledge** to executives engaged in strategic decisions			

Specific resources have been allocated **(KM investment)** in the company for the systematic activities of creating, storing, sharing, and applying knowledge			
The company works on systematic acquisition of knowledge and provides continuous education and information programs for **knowledge development** (e.g., creation, sharing, application, etc.)			
In the company, the activities of "knowledge workers" who work within and/or in collaboration with external partners are encouraged and rewarded with incentive and **recognition mechanisms**			
The company considers the creation and sharing of knowledge as an integral part of staff assessments (**rewarded knowledge sharing**)			
The company pays attention to the practices to recover the knowledge of those who leave the company (**KM retention**)			

Answer ‘‘YES’’ or ‘‘NO’’ to the following statements related to additional KM managerial practices:

Items/practices	**Yes**	**No**
Our company has assigned a manager to the role of Knowledge Manager / Officer / leader		
Our company has a dedicated knowledge management office		

Appendix B: DoS and IoU results for each catgories of practices and at each application situations

B1. DoS and IoU for ‘‘KM methods’’ category (in the application with suppliers)

Conventional names of practices (Methods)	Codes for practices	Mean	SD	Degree of Spread (%)	Intensity of use
Lessons learnt	KM-M1	2.07	1.27	86.7%	51.7%
Knowledge cafes	KM-M2	1.33	1.16	68.3%	33.3%
Peer assist	KM-M3	1.75	1.22	83.3%	43.8%
Community of practices	KM-M4	1.32	1.16	75.0%	32.9%
Knowledge domain mapping	KM-M5	1.08	1.12	63.3%	27.1%
Enterprise social network analysis	KM-M6	0.93	1.16	50.0%	23.3%
Mentoring and coaching for knowledge retention	KM-M7	1.23	1.18	65.0%	30.8%
Case-based reasoning	KM-M8	1.68	1.32	75.0%	42.1%
Brainstorming	KM-M9	1.68	1.26	75.0%	42.1%
Online knowledge searches	KM-M10	1.78	1.33	78.3%	44.6%

B2. DoS and IoU for ‘‘KM methods’’ category (in the application with customers)

Conventional names of practices (Methods)	Codes for practices	Mean	SD	Degree of Spread (%)	Intensity of use
Lessons learnt	KM-M1	2.30	1.18	91.7%	57.5%
Knowledge cafes	KM-M2	1.38	1.18	70.0%	34.6%
Peer assist	KM-M3	1.98	1.21	88.3%	49.6%
Community of practices	KM-M4	1.47	1.16	78.3%	36.7%
Knowledge domain mapping	KM-M5	1.08	1.14	61.7%	27.1%
Enterprise social network analysis	KM-M6	1.20	1.31	56.7%	30.0%
Mentoring and coaching for knowledge retention	KM-M7	1.25	1.22	63.3%	31.3%
Case-based reasoning	KM-M8	1.87	1.40	76.7%	46.7%
Brainstorming	KM-M9	1.67	1.27	76.7%	41.7%
Online knowledge searches	KM-M10	1.60	1.32	73.3%	40.0%

B3. DoS and IoU for ‘‘KM applications of IT’’ category (at internal application)

Conventional names of practices (IT tools)	**Codes for practices**	**Mean**	**SD**	**Degree of Spread (%)**	**Intensity of use**
Email and voice mail	KM-IT1	2.88	1.18	98.3	72.1
Chat rooms and bulletin board systems (BBS)	KM-IT2	2.40	1.43	83.3	60.0
Wikis	KM-IT3	1.63	1.34	71.7	40.8
Video conferencing	KM-IT4	2.90	1.26	93.3	72.5
Database systems and shared folders	KM-IT5	3.25	0.97	98.3	81.3
Enterprise Resource Planning (ERP)	KM-IT6	2.07	1.59	75.0	51.7
Simple knowledge organization system (SKOS)	KM-IT7	0.98	1.35	45.0	24.6
Enterprise social media platforms	KM-IT8	1.62	1.56	63.3	40.4
Cloud computing	KM-IT9	2.22	1.50	78.3	55.4
Customer Relationship Management (CRM)	KM-IT10	2.13	1.53	76.7	53.3
Supplier Relationship Management (SRM)	KM-IT11	1.20	1.35	51.7	30.0
Artificial Intelligence (AI) systems	KM-IT12	1.00	1.34	45.0	25.0

B4. DoS and IoU for ‘‘KM applications of IT’’ category (in the application with suppliers)

Conventional names of practices (IT tools)	**Codes for practices**	**Mean**	**SD**	**Degree of Spread (%)**	**Intensity of use**
Email and voice mail	KM-IT1	2.40	1.33	90.0	60.0
Chat rooms and bulletin board systems (BBS)	KM-IT2	1.52	1.30	71.7	37.9
Wikis	KM-IT3	0.92	1.09	50.0	22.9
Video conferencing	KM-IT4	2.45	1.36	90.0	61.3
Database systems and shared folders	KM-IT5	1.62	1.39	70.0	40.4
Enterprise Resource Planning (ERP)	KM-IT6	1.25	1.46	55.0	31.3
Simple knowledge organization system (SKOS)	KM-IT7	0.80	1.20	38.3	20.0
Enterprise social media platforms	KM-IT8	0.98	1.19	50.0	24.6
Cloud computing	KM-IT9	1.42	1.37	66.7	35.4
Customer Relationship Management (CRM)	KM-IT10	1.17	1.29	58.3	29.2
Supplier Relationship Management (SRM)	KM-IT11	1.23	1.35	55.0	30.8
Artificial Intelligence (AI) systems	KM-IT12	0.65	1.10	33.3	16.3

B5. DoS and IoU for ‘‘KM applications of IT’’ category (in the application with customers)

Conventional names of practices (IT tools)	**Codes for practices**	**Mean**	**SD**	**Degree of Spread (%)**	**Intensity of use**
Email and voice mail	KM-IT1	2.55	1.21	93.3	63.8
Chat rooms and bulletin board systems (BBS)	KM-IT2	1.60	1.29	75.0	40.0
Wikis	KM-IT3	0.93	1.12	50.0	23.3
Video conferencing	KM-IT4	2.48	1.37	88.3	62.1
Database systems and shared folders	KM-IT5	1.70	1.38	75.0	42.5
Enterprise Resource Planning (ERP)	KM-IT6	1.17	1.39	51.7	29.2
Simple knowledge organization system (SKOS)	KM-IT7	0.80	1.22	38.3	20.0
Enterprise social media platforms	KM-IT8	1.10	1.35	50.0	27.5
Cloud computing	KM-IT9	1.47	1.38	68.3	36.7
Customer Relationship Management (CRM)	KM-IT10	1.87	1.52	70.0	46.7
Supplier Relationship Management (SRM)	KM-IT11	1.02	1.27	46.7	25.4
Artificial Intelligence (AI) systems	KM-IT12	0.77	1.18	38.3	19.2

B6. DoS and IoU for ‘‘KM-enabling management actions’’ category (at internal application)

Conventional names of practices (Management actions)	**Codes for practices**	**Mean**	**SD**	**Degree of Spread (%)**	**Intensity of use**
Project teams	KM-MM1	2.82	1.30	90.0	70.4
Knowledge strategy plans	KM-MM2	2.12	1.43	80.0	52.9
Knowledge development	KM-MM3	2.43	1.24	90.0	60.8
Collaborative KM	KM-MM4	1.97	1.22	83.3	49.2
Top management support	KM-MM5	2.02	1.33	81.7	50.4
Open sharing structure	KM-MM6	2.12	1.38	80.0	52.9
KM assessment	KM-MM7	1.57	1.49	63.3	39.2
Knowledge networking	KM-MM8	1.78	1.43	73.3	44.6
Trust building	KM-MM9	2.33	1.28	90.0	58.3
Knowledge protection	KM-MM10	2.53	1.37	88.3	63.3
Knowledge communication	KM-MM11	2.23	1.16	88.3	55.8
KM investments	KM-MM12	1.97	1.41	78.3	49.2
KM training	KM-MM13	1.75	1.43	70.0	43.8
KM recognition	KM-MM14	1.30	1.32	55.0	32.5
Rewarded knowledge sharing	KM-MM15	1.80	1.34	75.0	45.0
Knowledge retention	KM-MM16	1.65	1.31	73.3	41.3

B7. DoS and IoU for ‘‘KM-enabling management actions’’ category (in the application with suppliers)

Conventional names of practices (Management actions)	**Codes for practices**	**Mean**	**SD**	**Degree of Spread (%)**	**Intensity of use**
Project teams	KM-MM1	1.82	1.38	75.0	45.4
Knowledge strategy plans	KM-MM2	1.33	1.39	61.7	33.3
Knowledge development	KM-MM3	1.28	1.24	65.0	32.1
Collaborative KM	KM-MM4	1.52	1.30	71.7	37.9
Top management support	KM-MM5	1.32	1.24	61.7	32.9
Open sharing structure	KM-MM6	1.37	1.29	63.3	34.2
KM assessment	KM-MM7	0.98	1.23	48.3	24.6
Knowledge networking	KM-MM8	1.13	1.28	56.7	28.3
Trust building	KM-MM9	1.80	1.27	80.0	45.0
Knowledge protection	KM-MM10	2.40	1.43	83.3	60.0
Knowledge communication	KM-MM11	1.60	1.28	75.0	40.0
KM investments	KM-MM12	1.37	1.34	65.0	34.2
KM training	KM-MM13	1.03	1.23	55.0	25.8
KM recognition	KM-MM14	0.85	1.02	48.3	21.3
Rewarded knowledge sharing	KM-MM15	1.07	1.21	56.7	26.7
Knowledge retention	KM-MM16	0.92	1.11	50.0	22.9

B8. DoS and IoU for ‘‘KM-enabling management actions’’ category (in the application with customers)

Conventional names of practices (Management actions)	**Codes for practices**	**Mean**	**SD**	**Degree of Spread (%)**	**Intensity of use**
Project teams	KM-MM1	1.80	1.36	75.0	45.0
Knowledge strategy plans	KM-MM2	1.25	1.41	56.7	31.3
Knowledge development	KM-MM3	1.45	1.28	70.0	36.3
Collaborative KM	KM-MM4	1.57	1.29	73.3	39.2
Top management support	KM-MM5	1.40	1.29	65.0	35.0
Open sharing structure	KM-MM6	1.37	1.29	61.7	34.2
KM assessment	KM-MM7	0.98	1.19	48.3	24.6
Knowledge networking	KM-MM8	1.23	1.28	61.7	30.8
Trust building	KM-MM9	1.73	1.30	78.3	43.3
Knowledge protection	KM-MM10	2.40	1.40	83.3	60.0
Knowledge communication	KM-MM11	1.67	1.24	78.3	41.7
KM investments	KM-MM12	1.45	1.42	63.3	36.3
KM training	KM-MM13	1.00	1.30	48.3	25.0
KM recognition	KM-MM14	0.80	1.12	43.3	20.0
Rewarded knowledge sharing	KM-MM15	1.08	1.32	51.7	27.1
Knowledge retention	KM-MM16	1.02	1.20	51.7	25.4

B9. DoS and IoU KM applications of IT (at all application situations)

Conventional names of practices (KM applications of IT)	**Degree of Spread (%)**			**Intensity of use**		
	Internally	With Suppliers	With Customers	Internally	With Suppliers	With Customers
Email and voice mail	98.3	90.0	93.3	72.1	60.0	63.8
Chat rooms and bulletin board systems (BBS)	83.3	71.7	75.0	60.0	37.9	40.0
Wikis	71.7	50.0	50.0	40.8	22.9	23.3
Video conferencing	93.3	90.0	88.3	72.5	61.3	62.1
Database systems and shared folders	98.3	70.0	75.0	81.3	40.4	42.5
Enterprise Resource Planning (ERP)	75.0	55.0	51.7	51.7	31.3	29.2
Simple knowledge organization system (SKOS)	45.0	38.3	38.3	24.6	20.0	20.0
Enterprise social media platforms	63.3	50.0	50.0	40.4	24.6	27.5
Cloud computing	78.3	66.7	68.3	55.4	35.4	36.7
Customer Relationship Management (CRM)	76.7	58.3	70.0	53.3	29.2	46.7
Supplier Relationship Management (SRM)	51.7	55.0	46.7	30.0	30.8	25.4
Artificial Intelligence (AI) systems	45.0	33.3	38.3	25.0	16.3	19.2

B10. DoS and IoU KM-enabling management actions (at all application situations)

Conventional names of KM practices (Management actions)	**Degree of Spread (%)**			**Intensity of use**		
	Internally	With Suppliers	With Customers	Internally	With Suppliers	With Customers
Project teams	90.0	75.0	75.0	70.4	45.4	45.0
Knowledge strategy plans	80.0	61.7	56.7	52.9	33.3	31.3
Knowledge development	90.0	65.0	70.0	60.8	32.1	36.3
Collaborative KM	83.3	71.7	73.3	49.2	37.9	39.2
Top management support	81.7	61.7	65.0	50.4	32.9	35.0
Open sharing structure	80.0	63.3	61.7	52.9	34.2	34.2
KM assessment	63.3	48.3	48.3	39.2	24.6	24.6
Knowledge networking	73.3	56.7	61.7	44.6	28.3	30.8
Trust building	90.0	80.0	78.3	58.3	45.0	43.3
Knowledge protection	88.3	83.3	83.3	63.3	60.0	60.0
Knowledge communication	88.3	75.0	78.3	55.8	40.0	41.7
KM investments	78.3	65.0	63.3	49.2	34.2	36.3
KM training	70.0	55.0	48.3	43.8	25.8	25.0
KM recognition	55.0	48.3	43.3	32.5	21.3	20.0
Rewarded knowledge sharing	75.0	56.7	51.7	45.0	26.7	27.1
Knowledge retention	73.3	50.0	51.7	41.3	22.9	25.4