UNIVERSITY OF NAPLES FEDERICO II

AND

UNIVERSITY OF BERGAMO

DOCTORAL PROGRAM

IN

TECHNOLOGY, INNOVATION AND MANAGEMENT

XXXV CYCLE

MANAGING KNOWLEDGE IN THE ERA OF DIGITAL TRANSITION

TUTOR:

PROF. ROBERTO CERCHIONE

PROF. EMILIO ESPOSITO

PHD CANDIDATE:

EUGENIO OROPALLO

ID: 1067722

DOCTORAL PROGRAM CORDINATOR:

PROF. RENATO REDONDI

Summary

1 INTRODUCTION

Much focus has been placed on Knowledge Management (KM) field over the past 20 years (Chaudhuri et al., 2021; Usai et al., 2018), and the discipline has developed into an interdisciplinary topic that connects many other fields and sectors (Boisot, 1998; Del Giudice & Maggioni, 2014; Edvinsson, 1997; Nonaka, 1994; Roos & Roos, 1997; Wenger, 1999). As a result, various models and frameworks were developed (Intezari et al., 2021). This is because KM is becoming increasingly important to the success of businesses across all sectors in today's highly competitive, global markets (Ardito et al., 2021; Cerchione et al., 2020; Del Giudice et al., 2017; Dezi et al., 2021).

In this background, the concept of knowledge has been studied from a variety of levels, including what knowledge is (Lin & Ha, 2015), where it is embedded (Buenstorf & Costa, 2018; Marjanovic, 2021), and how it can be classified (Holsapple, 2005; Nonaka, 1994) (Holsapple, 2005; Nonaka, 1994).

As far as the first level (*what it is*), Alavi and Leidner (2001) stress that knowledge is a multifaceted entity that is contemporary:

1) a state of mind through which individuals expand their knowledge and apply it to the organisation's needs;
2) an object that can be viewed as a commodity that can be stored and manipulated;
3) a process that needs the application of adequate expertise;
4) a condition of access to information (accessibility of the knowledge objects);
5) an ability to interpret data and information and ascertain what information is necessary for decision-making.

For Lin and Ha (2015), knowledge is the ability to apply relevant information for a purpose, in which:

1) ability implies the availability of a human or computer processor with adequate expertise to process the relevant information;

2) relevant information includes the contextual information and the specific information related;

3) purpose may be to find a solution, decide on an issue, or get an understanding or appreciation of a subject.

Newell (1982) assumes that knowledge is conveyed in usable representations, including symbolic, visual, audio, mental, digital, behavioural, and other patterns in time and space. Newell (1982) also underlines that when a specific representation is found that representation is usable by the processor and for that processor, that representation is knowledge. This latter point highlights that the author admits the possibility that functional representations exist for both human processors and non-human-based processors, like computers. This conclusion is also shared by Holsapple (2005) and Lin and Ha (2005), opening the possibility of digital knowledge management that has arisen as a relevant debate recently in the field of knowledge management (Cerchione et al., 2023). Digital knowledge differs from other knowledge dimensions not for an epistemological dimension but for the different way to be embedded in the stocks or flows.

Two contrasting perspectives have been considered in the literature to analyse digital knowledge management: exclusion and identification perspective (Holsapple, 2005; Kashav et al., 2021). The *exclusive perspective* considers KM as a strictly human and

social phenomenon and, in stark contrast, the *identification perspective* sees knowledge management primarily as a renaming of the various monikers and variants of digital technologies, such as data processing systems, information systems, information technology, planning of enterprise resources (ERP), intranet systems, data warehousing.

In the literature, it is not uncommon to come across the idea that knowledge management has little or nothing to do with technology. Instead, in this scenario, knowledge management concerns human relations, interpretations, processes, resources and culture. However, the exclusive point of view goes a step further to explicitly or even emphatically exclude digital knowledge from the KM domain, in fact it considers the supposed digital knowledge as a mere enabler to facilitate the practice of KM.

By focusing on digital technologies as the core of the KM, the identification vision tends to be unbalanced, paying inadequate attention to the many human elements of the KM. These elements include trust, ethics, incentives, human relationships, leadership, culture, organizational infrastructure, social networks, social capital, creativity and innovation, strategy, best practices, human skills, knowledge-sharing skills, and learning. Clearly, such human aspects of KM deserve careful consideration, as they are likely to determine how digital technology is applied in an organization and whether such will positively impact it.

The *identification perspective* is based on a conception of knowledge advanced by Newell (1982): knowledge is what is conveyed in usable representations. These representations include symbolic, visual, audio, mental, digital, behavioural and other patterns in time and space. When it turns out that a specific representation is usable by a processor, it is knowledge for that processor. There are, of course, degrees of usability related to the

clarity, significance, relevance and significance of a given representation in a particular situation faced by the processor. There are also many attribute dimensions to characterize an instance of knowledge and its degree of usability for a particular processor can be a function of where it is on these dimensions (Holsapple, 2005). Note that this definition of knowledge does not depend on the nature of its processor. It does not exclude computer-based processors; nor does it define knowledge in terms of information (as a synonym for information or in contrast to information). For the following discussion, we adopt Newell's neutral but very rich and unifying conception of knowledge, admitting the possibility that there are usable representations for both human and computer-based processors.

Hence, digital knowledge can be defined as the knowledge that requires a digital processor to be developed to make or begin with digital representations.

As far as the second level (*where it is embedded*), Jones et al. (2015), following the assumption of Alavi and Leidner (2001), stress that knowledge is a complex and multifaceted concept and highlight that knowledge is embedded in many entities and/or activities in an organisation, including the organisation's culture, policies, documents, and employees.

Going further, Dalkir (2013) assume that knowledge is a valuable commodity embedded in products (especially high-technology products) and employees' personal knowledge. Dalkir (2013) also underlines that knowledge may be viewed as a commodity or an intellectual asset that possesses some paradoxical characteristics radically different from those of other valuable commodities:

1) Use of knowledge does not consume it;

2) Knowledge transfer does not result in losing it;

3) Knowledge is abundant, but the ability to use it is scarce;

4) Much of the valuable knowledge of an organisation does not stay in the organisation.

These four characteristics make the knowledge a unique resource for the organisations and make its managing very peculiar.

As far as the third level (*how it can be classified*), Polanyi (1958) evidences that knowledge can also be classified into tacit and explicit knowledge. Tacit knowledge resides in the human's mind and entails a body of perspectives, perceptions, beliefs, and values. It is difficult to access without ongoing engagement with the knowledge holder. On the other hand, explicit knowledge is articulated, codified, and communicated in symbolic form and/or natural language. It can be accessed and used without the knowledge creator or holder being present. Starting from the contribution of Polanyi, Nonaka & Takeuchi (1995) classify the process of knowledge creation from two dimensions:

1) *Epistemological dimension*, concerning the tacit and explicit form of knowledge;

2) *Ontological dimension* concerning the different knowledge levels: individual, group, organisation, inter-organisation.

By crossing the epistemological classification, the authors have proposed a model of knowledge creation within organizations that manages to intercept all the possible combinations of knowledge that a person can manage. While consciously neglecting the possibility of a technological dimension, Nonaka and Takeuchi (1995) do not exclude that

with technological progress, the digital dimension, in addition to being a simple support tool, can represent a truly independent space for creation of knowledge.

With a different point of view, Holsapple (2005) classifies knowledge in terms of:

- *descriptive knowledge*, that describe the nature of some world: it could be a future world, the past world, the current world, a hypothetical world, or an expected world.
- *procedural knowledge* that is a representation that a given processor can use to accomplish a series of steps;
- *reasoning knowledge* that specifies what conclusion is valid when certain circumstances exist. It is knowledge that is concerned with logic, correlation, synchronicity, analogy, and perhaps even causality. When a representation is used to determine why something is the way it is or what action is suitable in a specific circumstance, that representation is communicating reasoning knowledge to a processor when it.

When moving from one state of descriptive knowledge to another using specific procedural knowledge, a processor may use reasoning knowledge. For instance, rules may exist that specify the method to use when extracting information from data or the line of reasoning that will result in a sound choice in a particular circumstance.

Reasoning knowledge and *procedural knowledge* can be easily externalised for sharing and effectively codified for digital processing. *Descriptive knowledge* is more subjective and ambiguous and is difficult to codify.

Starting from these classifications and theoretical conceptualizations, over time very disparate research tendencies have emerged and developed in various fields, such as the

impact of knowledge risk management on performance (Durst, 2019), market knowledge sourcing determinants (Endres et al., 2020), heterogeneous knowledge ties (Maghssudipour et al., 2020), the role of an international joint venture in managing and exploiting knowledge (Bamel et al., 2021), and KM and green innovation (Abbas & Sağsan, 2019; Shahzad et al., 2021).

Following this growing interest, several reviews on the topic of KM have been published over time, focusing on many aspects: major trends and challenges in KM (Asrar-ul-Haq & Anwar, 2016), key KM approaches (Alexandru et al., 2020), processes for knowledge exploration and exploitation (Centobelli et al., 2017), KM in strategic alliances (Bresciani et al., 2018), KM and firm performance (Asiaei & Bontis, 2019; Cardoni et al., 2020; Inkinen, 2016) and digital knowledge (Anwar et al., 2022; Martínez-Navalón et al., 2023).

In today's dynamic global business competition, especially digital knowledge is becoming a strategic factor for all industries to survive; in this way, organisations try to collect more data or information than others (Kaklauskas & Kanapeckiene, 2005; Tsouri et al., 2021). The proliferation of Internet-based software applications and the implementation of predictive techniques has facilitated conversations, interactions and communications of users in a network, such as a supply chain, favouring an increasingly intense flow of data and information that describes in more or less direct way parts of the network (Liu et al., 2020; Thomas & Thomas, 2012). For this reason, these programs have radically changed how different actors in the network communicate and find relevant information and pushed them to accumulate data (Gansterer et al., 2021; Macnamara & Zerfass, 2012). However, to achieve efficient and effective KM processes, the mere accumulation of knowledge is not enough, and the systematic strategies for knowledge creation, processing, sharing, and execution are of utmost importance (Pantic-Dragisic &

Söderlund, 2020; Raudeliūnienė et al., 2018). These processes are fundamental for organisations to innovate and create organisational routines (Andrade Rojas et al., 2018; Calvo-Mora et al., 2016), commercialise new products, improve corporate performance (Tseng & Lee, 2014), enhance employee productivity, and reduce the variety of redundancies (Martinsons et al., 2017), and strengthen market and financial performance (Apa et al., 2018; Javi et al., 2018; Vestal & Danneels, 2018).

The diffusion of Industry 4.0 (I4.0) enabling technologies was one of the technological revolutions that impacted most KM processes. I4.0 is characterised by a mass creation of smart objects for everyday life (e.g., smart mobility, home applications) and technologies for working routines like artificial intelligence (AI), Internet of things (IoTs), big data analytics (BDA), blockchain. I4.0 technologies have great versatility, so they have penetrated every working sector (e.g., food, medical, luxury, services) and in different phases of the value creation process (e.g., procurement, production, logistics, distribution) (Foster-McGregor et al., 2021; Miranda et al., 2021; Pace et al., 2019; Stornelli et al., 2021). I4.0 have both a technical and a social dimension regarding the people interacting with them (Oks et al., 2017). If, from a technical point of view, digital reality pushes products and services to have their "virtual twins", the diffusion of social media is creating "virtual twins" for people, expanding the possibilities of communication and, more generally, the interaction of virtual users (Thomas & Thomas, 2012) and radically changing the way people interact and seek information (da Silva Alfenas et al., 2021; Galli et al., 2019; Poy & Schüller, 2020). From the synergy of I4.0 and social media tools, it has been possible for organizations to obtain, store and process a large amount of data from inside and outside (Escribano et al., 2009; Mazzola et al., 2016). In this evolving scenario, digital knowledge has become a fundamental resource in the KM domain

(Acerbi et al., 2020; Eaton & Pasquini, 2020; Rajabion et al., 2019). For instance, Nambisan (2017) and Guo et al. (2021) analyse how organisational axioms and paradigms have changed by the rise of digitalisation and KM processes renew the knowledge base and improve innovation performance. Specifically, authors identified four main characteristics in new organisational axioms and theories:

- Dynamic problem–solution design pairing: problem-solution design pairs are developed, twisted, merged, ended, and refined in scattered, parallel, and heterogeneous ways by digital innovation management:
- Socio-cognitive sensemaking: a crucial component of managing digital innovation is shared cognition and joint sensemaking. Narratives are a vehicle for this type of socio-cognitive sensemaking and are embedded in digital artefacts and supported by digital technologies;
- Technology affordances and constraints: explains how and why the same technology can be redeveloped by different actors or has different innovation results in various contexts by taking into account the use of digital technology as a set of affordances and constraints for specific innovating actors;
- Orchestration: problem-solution matching is a micro-foundation for orchestrating digital innovation, and digital technologies are playing an increasingly important role in this process.

Besides, organisational processes affecting KM strategies are likely changing with the direction identified by adopting advanced digital solutions (e.g., advanced business analytics, digital platforms, machine learning) for product and process innovation (Fakhar Manesh et al., 2021; Li et al., 2018).

Additionally, many studies are concentrating on the function of digital innovation in KM systems in the current digital era, when the pervasiveness of technology and digital solutions in everyone's life is obvious (Crupi et al., 2020; Di Vaio et al., 2021). Digital technology has unquestionably had a significant influence on the development of organisational strategy and KM procedures: this has motivated scholars to investigate how these technologies have an impact on society and the economy (Del Giudice et al., 2021; Magni et al., 2021). The major conclusions of those recent research focused on the connections between innovation, KM systems, business performance, and sustainability in a long-term value-generating process for society (Crupi et al., 2020; Del Giudice et al., 2021; Di Vaio et al., 2021; Magni, Scuotto, et al., 2021).

The Agile methodology is one of the primary organisational paradigms used by businesses, manufacturing and services, operating in highly dynamic and rapidly evolving environments to create goods and services through the optimisation of resources and customer satisfaction by involving them directly in the design process and/or production (Capaldo & Volpe, 2021; Cerezo-Narváez et al., 2021a; Holbeche, 2018).

Given the adoption of 4.0 technologies in many developed economies countries' industrial fabric and how these technologies impact knowledge management by generating larger and new data volumes, it is also important to focus on specific cases that use technology to, such as agile approaches.

The relevance to focus on agile methodology is because one of the paradigms most adopted by businesses is the agile paradigm, allowing them to leverage networks, create new synergies and strategies, and seize opportunities faster than their rivals (Cerezo-Narváez et al., 2021). The agile approach is a broader phenomenon that has changed

organisational culture, mindset, and skills at all organisational levels (Holbeche, 2018). To compete with the global market leaders, organisations require efficient and effective processes and current knowledge of their environment as possible (Cerezo-Narváez et al., 2021). This objective is frequently pursued through the creation of agile team that are multidisciplinary, made up of people with high skills, able to transform abstract ideas into innovative products through the use of advanced technologies such as emerging technologies of the most recent digital revolution (Beaumont et al., 2017; Brand et al., 2021; Grass et al., 2020, 2020).

The beginning of I4.0, created a storm in the global market by introducing intelligent manufacturing by robots and cyber-physical systems (CPS), a huge flow of data in the Internet of Things (IoT), possibility to analyse a fund data and information through the use of artificial intelligence (AI) technologies and support the interaction of remote operators through the use of virtual or augmented reality systems (Frederico et al., 2020; Rana & Sharma, 2019). According to the Mckinsey report, the presence of technologies related to I4.0 is present intensively in the realities of developed countries, while it is growing strongly in developing countries (Bai et al., 2020).

This increasingly growing phenomenon has led to an evolution in the agile approach to be capable of adapting the newest technologies available and rapidly changing the internal and external environments that these technologies entail.

In a scenario like this, to be up-to-dated about the external environment and internal available resources and processes, it is even more necessary to have knowledge management techniques that are as efficient and effective as possible.

Holz & Maurer (2003) had already analysed how KM was a fundamental node within any agile process and how, for its success, it was necessary to have the right mix of interactive and deferred knowledge flows.

If the project respects the values of the agile manifesto, a greater emphasis must be placed on written documentation; however, the cost of creating and updating this documentation is one reason it is minimized (Holz & Schafer, 2003).

At the same time, the complete lack of documents in agile projects entails significant disadvantages, including the loss of time by the experts answering the same questions; a workgroup cannot remember a previously provided solution for a similar problem, direct exchange of knowledge between members of different teams is difficult or even unlikely if they cannot see each other available; finally, important information is lost once its owner leaves the project or company permanently (Holz & Schafer, 2003).

Furthermore, in the context of the agile software development cycle, there are numerous proposals to improve KM, particularly the communication and sharing of information within and between different teams. The result is a collection of data and information that its users can update, and therefore by all those with access to it with a lower management cost (Yanzer Cabral et al., 2014).

In summary, agile and KM practices present common activities that can benefit organizations by promoting knowledge sharing, knowledge reuse, team communication, and collaborative processes (Napoleão et al., 2021).

The diffusion in recent years of I4.0 enabling technologies and Web 2.0 tools impacted organisation processes, like the agile and KM ones, enhancing communication velocity

and possibilities, hence widening the decision-making field (Foster-McGregor et al., 2021; Miranda et al., 2021; Pace et al., 2019; Stornelli et al., 2021) .

Undoubtedly, KM results a strategic factor for all industries to survive; organisations try to collect more data or information than others (Kaklauskas & Kanapeckiene, 2005; Tsouri et al., 2021). The proliferation of digital software applications and the implementation of predictive techniques in ordinary processes has pushed the network communications generating an intense flow of data and information (Liu et al., 2020; Thomas & Thomas, 2012). Eemployee's way to communicate is radically changed (Gansterer et al., 2021). To effectively manage KM processes, the organisation has developed systematic techniques for knowledge creation, processing, sharing, transfer and application to manage and integrate even digital knowledge (Raudeliūnienė et al., 2018; Pantic-Dragisic and Söderlund, 2020).

Moreover, as the COVID-19 pandemic revolutionized our lifestyle, new research has emerged within these KM research streams intending to assess the applicability of innovative KM models in times of crisis. Initial research has examined how the KM process contributed to knowledge exchange during the initial phase of COVID-19 (Mennini et al., 2021), while other studies have explored how the business model has changed in the post-COVID-19 era from a KM perspective (Li et al., 2021).

In these changing times, the supply chain is one of the systems that changed the most (Liu et al., 2020). But this looks to be normal, in fact, as demonstrated by many papers, the supply systems have historically undergone a continuous and profound evolution through the different socio-economic and technological revolutions that changed the way of thinking the supply chain, influenced their organisational configuration, objectives, and

relations between the various suppliers' tiers and customers (Bahar et al., 2020; Nedelko, 2021; Pickernell, 1997; van Kooij, 1991; Womack et al., 2007). In the 1970s, the supply systems were characterised by a star-shaped organisation based on dyadic customer-supplier relationships. Three main typologies of supplier were identified in a star-shaped organisation: capacity supplier; specialisation supplier; and supply-type supplier (Berthomieu et al., 1983; Chaillou, 1977). In the 1980s, supply systems shifted toward a pyramidal-shaped organization based on mutual trust between customer and first-tier supplier (FTS), which grew through information exchange and knowledge sharing (Asanuma, 1989; Lamming, 1993; Sako, 1992). The literature was influenced by the transaction costs theory (Williamson, 1979), the theory of the firm as a set of contracts (Klein et al., 1978)) and the cooperative game theory of the firm (Aoki, 1984). In the 1990s, supply systems had a pyramid-shaped organisation with a strong influence in coordination by the customer (Colombo & Mariotti, 1998; Hines, 1994): customers drove the supply system interactions, which fostered the circulation of knowledge through their actions, minimized the opportunism of individual suppliers, and facilitated the innovation process. The literature was affected by evolutionary theory (Nelson et al., 1982) and the debate on strategic alliances (De Toni & Nassimbeni, 1995; McIvor, 2000; Wong, 1999). In the 2000s, the expansion of globalization had a significant impact on supply networks. Numerous experts have highlighted both the motivations that prompted firms to globalize and the effects of globalization on the supply chain (Gelderman & Semeijn, 2006; Levy & Grewal, 2000; Quintens et al., 2006; Szász & Demeter, 2015)). KM has started to became an increasingly critical factor in supply system governance during this period (Blome et al., 2014; Yang et al., 2009), and the use of appropriate information systems has become fundamental (Prasad & Sounderpandian, 2003). In this period, the resource-

based view theory (Barney, 1991) and the debate on extended and virtual enterprises influenced the literature (Browne & Zhang, 1999; Muñoz et al., 2013; Seuring & Müller, 2008; Vachon & Klassen, 2008), illustrating how sustainable resource management has begun to penetrate the business management paradigm. Environmental management solutions for supply chains have garnered significant attention during the past decade, as environmental standards influencing industrial output have become more stringent than before (Birou et al., 2019; Muñoz et al., 2013; Seuring & Müller, 2008; Vachon & Klassen, 2008). Management aspects such as resilient and risk supply system (Clemons & Slotnick, 2016; Umar et al., 2021; Y. Wang et al., 2021), financial supply chain (Jüttner & Maklan, 2011), green supply chain and circular supply system (Alonso-Muñoz et al., 2021; Phawitpiriyakliti et al., 2020) have received more attention highlighting how the supply chain is a complex circular process where the circulation of information and knowledge plays a crucial role (Dao et al., 2011; Schrettle et al., 2014). The impact of latest digital and industrial revolution improvements, notably I4.0 technology, on KM practises has been significant (Fragapane et al., 2022; Kumari et al., 2018; Majeed & Rupasinghe, 2017; Szász et al., 2021). In fact, on workplace, technology implementation positively supported KM, innovativeness and decision-making processes: with the use of I4.0 tools, organisations have been able to store and process a large amount of data both internally and externally (Feng & Shanthikumar, 2018; Schniederjans et al., 2020; Sedita et al., 2021). The new form of this digital data pushed people to approach to different way in managing the processes where digital data is generated: the connected digital knowledge has added importance KM methodology (Acerbi et al., 2020; Z. Li, Wang, et al., 2018b), resulting in a critical component in creating a balanced and more easy knowledge diffusion in the supply chain and bringing into question the existing

innovation and organisational learning theories (Natalicchio et al., 2017). In this period, the literature on supply chain was influenced by the debate on sustainable development and circular economy (Genovese et al., 2017) and was affected by a variety of theories, which deal with a broad set of disciplines including sociology, economics, philosophy, politics, governance, management, and science of complex systems. Concurrently, technologies from the most recent industrial revolutions helps in the management of the expanding complexity of supply chains (Cerchione et al., 2023), leading in the development of new skills and methods of thinking within the supply chain network, such as the necessity to interact with others to remain competitive (Durach et al., 2020; Patrucco et al., 2022) and with the positive effect of enhancing regional development where the supply chain operates (Maghssudipour et al., 2020; Sedita et al., 2021; Telles et al., 2020). Today the supply chain is a multi-objective system (i.e., economic, productive, strategic, environmental, social) crossed by a variety of flows (i.e., financial, material, information, knowledge) that necessitates reaching out to and engaging with a variety of actors, including suppliers, customers, governments (Arena et al., 2022; Solaimani & Van der Veen, 2021). In such a complex system, the management of KM activities, specifically knowledge transfer and sharing, appears to be an essential answer to the current globalisation and sustainable development issues. Nevertheless, there is a large body of literature indicating that KM is becoming a key strategic factor in supply chain management and that its importance is growing, but the process of knowledge diffusion between the various players in the supply chain still appears to be neglected in favour of focusing solely on the customer-supplier relationship (Benbouja et al., 2021; Najjar et al., 2020). This is a gap in the literature as the FTS plays a central role within the supply chain since it develops relationships with the customer upstream and

downstream with the second-tier supplier (STS) (Esposito & Passaro, 2009; Hines, 1994; Mesic et al., 2018; Stock & Boyer, 2009). Its strategy and behaviours, together with those of the customer, affect the characteristics of the supply chain. In other words, the supply chain is not the sum of dyadic relationships, but it can be seen as a holon that has its own identity but is also an integral part of a superior system (the supply system). Consequently, the analysis of the process of knowledge diffusion in the supply chain should not be reduced exclusively to the dyadic relationship between customer and FTS but should be studied as a whole through the triadic relationships between customer, FTS and STS. Accordingly to this necessity, some studies have begun to investigate how customer-FTS-STS relationships in an open innovation environment can recreate an environment with high innovative potential, in which supply chain risks can be better addressed (Durach et al., 2020; Patrucco et al., 2022); where the quality delivered to end customers can be greatly improved if the entire supply chain is integrated upstream and downstream.

The rest of the thesis is structured as follows: in chapter 1 there is a tertiary review on the topic of KM in order to highlight state of the art on the topic and highlight the actual research advancement/gap; in chapter 2, there is a state-of-the-art analysis of KM research advances to highlight not only the advances but also the current pending issues; in chapter 3 there is a focus on the SECI model facing on the digital transition, analysing how the main KM model is changing under the push/pull of I4.0 and Web 2.0; in chapter 4 a multiple case study is carried out to validate on the field how KM is evolved, in chapter 5 a quantitative analysis on how to evaluate the knowledge diffusion in a supply chain is conducted and in chapter 6 it is synthesised the concluding remarks.

2 What do you know about knowledge: A tertiary study on knowledge management.

2.1 Objectives

Considering the mentioned context, this chapter aims to explore the evolution of KM research, in order to understand which research topics are studied and to derive interesting research directions that could be pursued or resumed. As a starting point, the research wanted to approach a broad perspective starting from secondary documents (i.e., review, overview) that are not only simply focused on the theme of KM, but each provides an evolutionary perspective of particular themes related to KM.

This will make it possible to understand what the main themes in the discussion on KM are and what are the main gaps that have not found constant interest over time either due to time or interest.

In order select, gather, classify, and analyse the findings from secondary research, a novel tertiary review is necessary. With these assumptions in mind, the purpose of this chapter is to design and implement a tertiary review methodology to offer a thorough and current overview of the topic of KM, starting with the results of prior secondary studies that have been published in the body of literature. This study seeks to evaluate both the specific responses to the research issues raised by earlier secondary studies as well as the development of literature gaps over time. Therefore, the purpose of this analysis is to give academics and industry professionals a research compass. The results show a substantial correlation between the analysis perspectives and the reviews' reported research gaps.

2.2 Review methodology and data collection

Comparatively, while a literature review aims to compile primary studies on a research question, a tertiary review examines secondary contributions, such as literature reviews and overviews. Tertiary studies collect data from secondary sources and analyze the findings. These are required when there have been an excessive number of published reviews on a certain subject; hence, it is important to trace the historical process of research gaps uncovered by the literature reviews (Donthu et al., 2021).

This contribution is the first to focus exclusively on the evolution of KM secondary studies published in the field through formal analysis (e.g., review protocol, review type, keywords), and to categorize the objectives addressed by the reviews from the perspective of the triple bottom line. Besides the well-known descriptive analysis, the purpose of this paper is to develop a novel tertiary methodology to assess the evolution of literature gaps that have emerged over time, as well as the specific answers to research questions formulated by previous secondary studies that have been published in the body of literature, in order to provide a research compass for both academicians and practitioners. This methodology enables researchers to blend the strengths of other literature review methodologies, such as narrative, systematic, bibliometric, and meta-analytic, while also overcoming the shortcomings of these other literature review methodologies. Systematic reviews are the synthesis of primary research studies that employ and define precise and reproducible methodological procedures to identify, summarise, critically appraise, and analyse all significant aspects of a particular research area (Petticrew & Roberts, 2006; Pittaway & Cope, 2007; Tranfield et al., 2003). There is evidence that the formulation of the review methodology in systematic reviews assures the analysis's consistency and correctness. Bibliometric analysis is a method for analysing many articles in a specific

field while narrowly focusing on the contents of the chosen material. It is based on the usage of certain metrics, such as the number of citations (Aria & Cuccurullo, 2017; Cobo et al., 2011).

Figure 1 reports a conceptual scheme of the methodology adopted in this paper, which consists of three main steps:

1. ***Material collection phase***. It includes a detailed discussion about the academic database and keywords used to collect reviews.

2. ***Material pre-processing***. It includes all the pre-processing operations to clean data and remove spelling mistakes from the database.

3. ***Results analysis***. It consists of three sub-phases:

a. *Performance analysis*. This phase classifies publications by different perspectives:

i. Reviews by time. Chronological distribution of publications

ii. Reviews by country. Publications distribution per country

iii. Reviews by journal. Publications distribution by journal

iv. Reviews by subject area. Publications distribution by subject area

v. Most relevant contributions. Analysis of most cited publications.

b. *Network analysis*. In this phase, statistical and mathematical methods are used to examine various aspects of a research field from an objective and quantitative perspective, and identify different maps based on the research field structure (De Bellis, 2009; Mora et al., 2019). These maps are complex networks in which two or more units can be interconnected with each other (Y. Ding, 2011; Mora et al., 2019) and they make it possible to understand "how specific research fields are conceptually, intellectually and socially structured" (Cobo et al., 2011). Once

defined the aspect of the paper to analyse (e.g., authors, journals, documents, cited references, institutions, and countries), it is possible to build a graph where the nodes are the bibliographical elements considered and the edges are the link between them (e.g., co-citation and co-occurrence). The similarity degree between each node affects the network connection degree (Mora et al., 2019) and according to the similarity criteria, connections in the network can be different. The most common criteria for measuring similarity are co-citation, coupling, and co-occurrence analysis (Glänzel & Thijs, 2011; He, 1999).

c. *Evolution analysis*. Finally, the third phase of the methodology is the most novel, distinguishing the proposed technique from standard literature reviews. A literature review study, generally, concludes with the formulation of a set of research questions related to the analysis of the publications, and the results are significantly polarised from the authors' perspectives due to their backgrounds and experiences. The proposed method for identifying research gaps is broken down into different steps. The first step is to categorise the research gaps. The gaps are identified by a triangulation procedure that involves two researchers, plus a third in case of doubt, analysing the entire text of the reviews and identifying the gaps revealed by previous secondary investigations. A final list of literature gaps on the topic under investigation is compiled. Typical gaps discovered include the need to conduct studies in other countries or industries to compare findings or increase knowledge of a specific issue and content-based gaps that contribute to developing a vivid and meaningful research agenda for practitioners and academics (Martins & Pato, 2019).

The details of each step are discussed in the following sections.

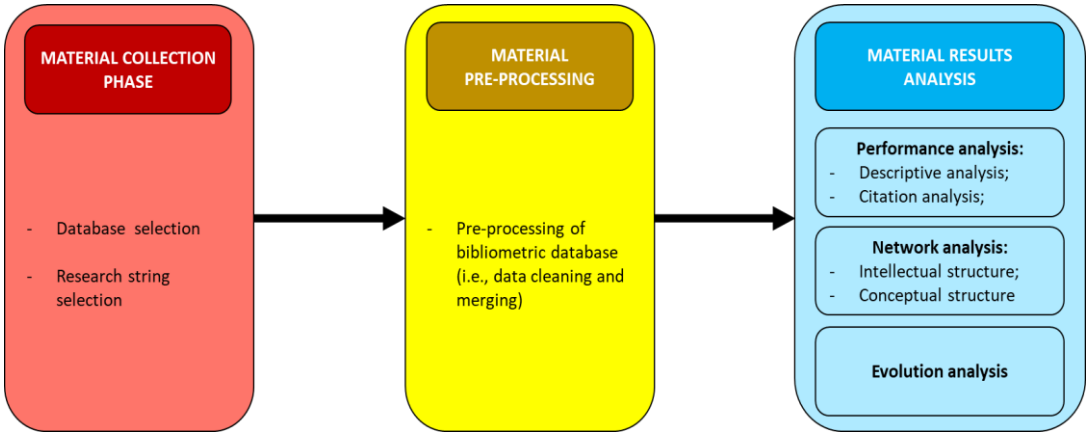


Figure 1 Review methodology proposed

Material collection phase

Data was collected from the Web of Science (WoS) database. This database represents a reliable and high-quality data source for literature analysis (Di Vaio et al., 2021; Johnsen et al., 2017; Rebs et al., 2019). The search string includes the reviews containing in the title the words ("knowledge management" OR "KM") AND ("review" OR "overview"); in this way all the documents dealing explicitly with the topic investigated in a review format are selected. The data collection phase was conducted in early 2022, and only contributions in the English language published between 1997 (the first year available in WoS database to collect data) and 2021 were considered in the final sample. Finally, conference proceedings and book chapters were excluded to ensure the quality of review analysis, and only articles and reviews published in peer-reviewed journals were included in the final sample (David & Han, 2004; Newbert, 2007). At the end of this phase, the total number of contributions considered for the following steps is 485.

During the abstract reading phase, only the literature reviews in the field KM are considered, while primary sources and contributions not in the KM domain were not

considered. After the analysis of abstracts, only 101 contributions were directly considered, while for 82 sources were further evaluated. At the end of the analysis of these contributions, 11 additional reviews were added to the final sample containing 122 contributions.

Material pre-processing

During this phase, the file including the database of reviews was submitted to a pre-processing process to avoid duplications for spelling mistakes or contractions (e.g., knowledge management and KM, bibliometrics and bibliometric analysis).

2.3 Result analysis and discussion

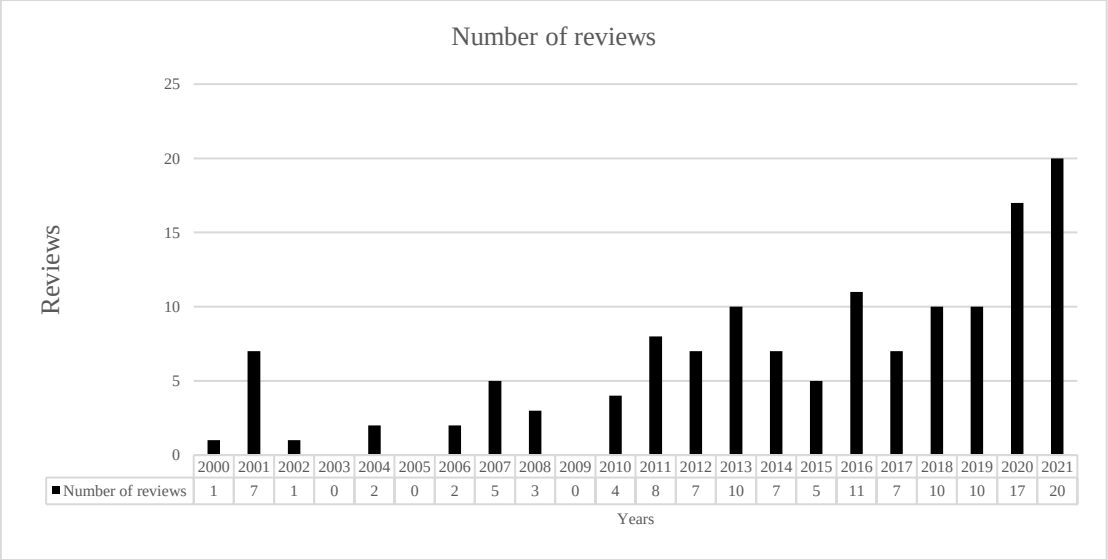
2.3.1. Performance and network analysis

This section reports the descriptive analysis results which are discussed in detail in the following subsections.

Reviews by time

The first analysis looks at the historical distribution of reviews plotted in Figure 2. KM initiatives have a long history; in the early 1990s, KM evolved as a scholarly field focusing on what knowledge is and how it could support an organisation (Mcinerney, 2002). The first systematic reviews appeared between 2000 and 2001. Gradually, particularly following the increased usage of computers during the third industrial revolution, there has been an increase in interest in both practical and theoretical elements of KM, specifically in knowledge creation aspects (Bray, 2007; Herschel & Jones, 2005); so, after 2010, there was a spread of reviews on knowledge management and this trend was also sustained by the fourth industrial revolution and the following transition; the

possibility to acquire, transfer, store and detailed data in a digital way increased debates about knowledge management possibility.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Number of reviews	1	7	1	0	2	0	2	5	3	0	4	8	7	10	7	5	11	7	10	10	17	20

Figure 2 Chronological distribution of reviews

Reviews by country

Following the historical distribution, it is necessary to analyse how KM interest in reviews is dispersed geographically. Regarding the publication of reviews on the topic with a full counting method (Table 1), Italy is the leading country (with 14% of reviews), followed by the United Kingdom (9%) and the United States (9%). The single country publication ratio (SCP Ratio) is the ratio between single country publications and total country publications. Generally, it is possible to assume that the topic is examined within the national scientific research network; except for China, the major country reviewers collaborate with up to 30%.

In Table 2, the citation score was employed as a ranking criterion rather than the number of reviews. Although the three leading countries are the same as those reported in Table 1, the United States takes the lead, followed by the United Kingdom and Italy. In general, using the number of reviews or the citation as a criterion does not significantly change the ranking: countries present in both the ranks are listed in cursive.

Table 1 Top 10 most productive countries

Country	**Reviews**	**Frequency**	**Collaborations rate**	**TC**	**Average Citation per Reviews**
ITALY	17	14%	63.33%	475	27.9
USA	11	9%	50.00%	4593	417.50
UNITED KINGDOM	11	9%	48.28%	653	59.4
CHINA	8	7%	27.59%	220	27.5
MALAYSIA	7	6%	31.03%	192	27.4
GERMANY	6	5%	27.59%	134	22.3
AUSTRALIA	4	3%	37.93%	131	32.8
SPAIN	4	3%	17.24%	168	42.0
THAILAND	4	3%	13.79%	131	32.8
IRELAND	4	3%	13.33%	128	32.0

Table 2 Top 10 most cited countries

Country	Reviews	Frequency	Collaborations rate	TC	Average Citation per Reviews
USA	11	9%	50.00%	4593	417.50
UNITED KINGDOM	11	9%	48.28%	653	59.4
ITALY	17	14%	63.33%	475	27.9
ICELAND	1	1%	3.70%	238	238.00
CHINA	8	7%	27.59%	220	27.5
MALAYSIA	7	6%	31.03%	192	27.4
SPAIN	4	3%	17.24%	168	42.0
NORWAY	2	2%	6.90%	163	81.5
GERMANY	6	5%	27.59%	134	22.3
AUSTRALIA	4	3%	37.93%	131	32.8

By considering the collaboration between the different countries in Figure 3, it is possible to highlight three different clusters of collaborations counted with a full counting method. This method was chosen because, with the exception of some counties that have joined the motor countries, there is a high single country publication rate, so the deviation of the results using the fractioned country method would be minimal. The first one (red cluster) is formed by USA, UK, and Italy. While USA and UK have been the first countries to be focused actively in research on KM, both for papers and reviews, Italy spreads later with a very high interest on the topic involving a lot of other nations, such as Russia, Czech Republic, and Brazil. The perspectives are various: from a theoretical research and

development point of view to review empirical perspectives in SMEs or healthcare sectors.

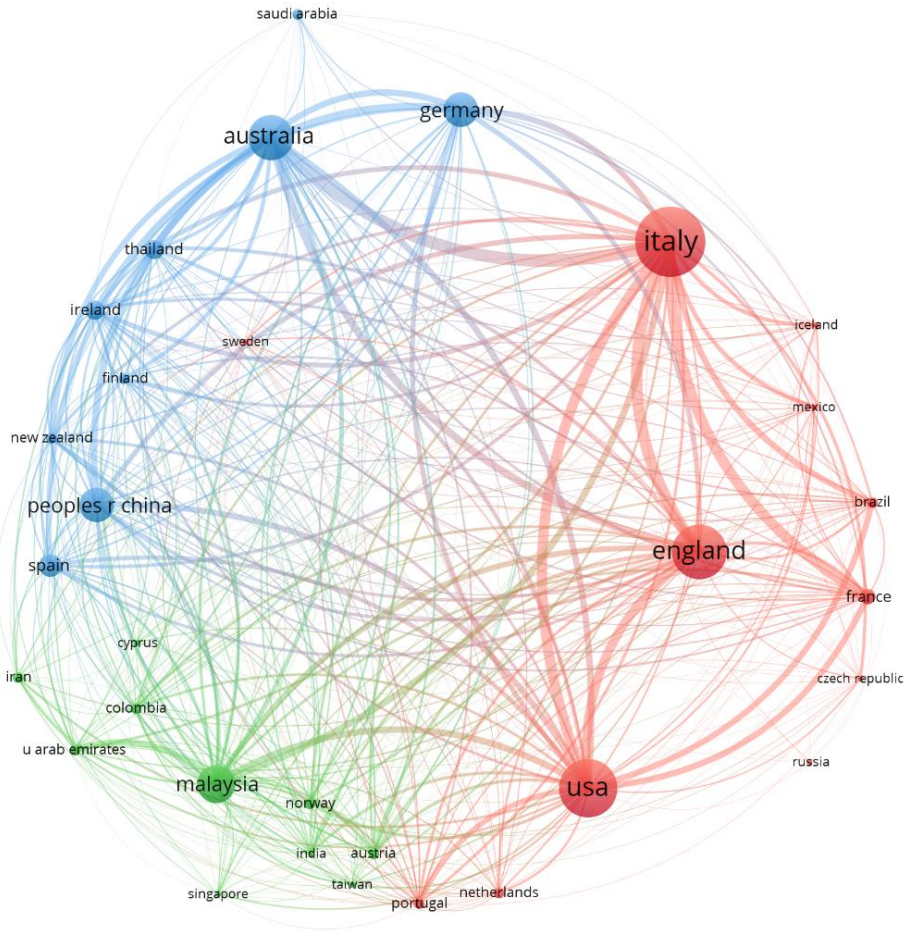


Figure 3 Countries' collaboration network

The second cluster (blue cluster) is formed by countries with a medium/low collaboration behaviour: China, Spain, Australia, and Germany, namely the most productive countries in this cluster, have a medium single country collaboration index. Considering the importance that in the twenty-first century KM gets, they tried to be up-to-date on the

topic through the collaboration with the USA and the United Kingdom before, and with Italy later. Most reviews in this field deal with the research and development perspectives.

The third cluster (green cluster) is formed by a group of countries with only 1 or 2 reviews but for Malaysia with a very recent interest in KM topic, specifically in computer and informatic aspects of the topic. However, it is fair to assume that collaboration between countries and researchers started to grow over time as interest in the topic increased (Akhavan et al., 2016; Qiu & Lv, 2014; Ramy et al., 2018; Y. Wang et al., 2018).

Reviews by journal and subject area

According to the analysis of reviews by journal, the *Journal of Knowledge Management* emerges as the leading journal for the publication (with 40 reviews), followed by the *Knowledge Management Research and Applications* (with 12 reviews) and *International Journal of Knowledge Management* (with 10 reviews) (Figure 4).

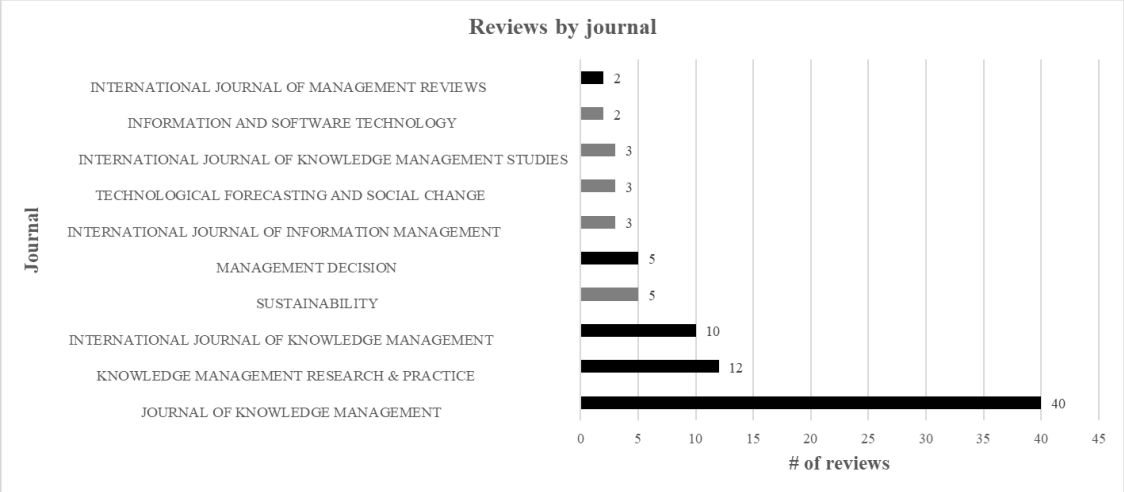


Figure 4 Reviews by journal

This outcome is justified by the fact that they are among the most relevant journals in the field of KM. However, journals that are not directly or primarily focused on KM, such as *Sustainability* (with 5 reviews), *Management Decisions* (with 5 reviews) and *Technology and Forecasting Social Change* (with 3 reviews), have been chosen for publication. This is because KM, as an interdisciplinary topic, is finding interesting applications in various environmental, managerial, and technological fields. Focusing on the function perspective considered in the review analysis in Figure 5, it is not surprising that half of the reviews have a research and development perspective, as KM is an ever-developing topic.

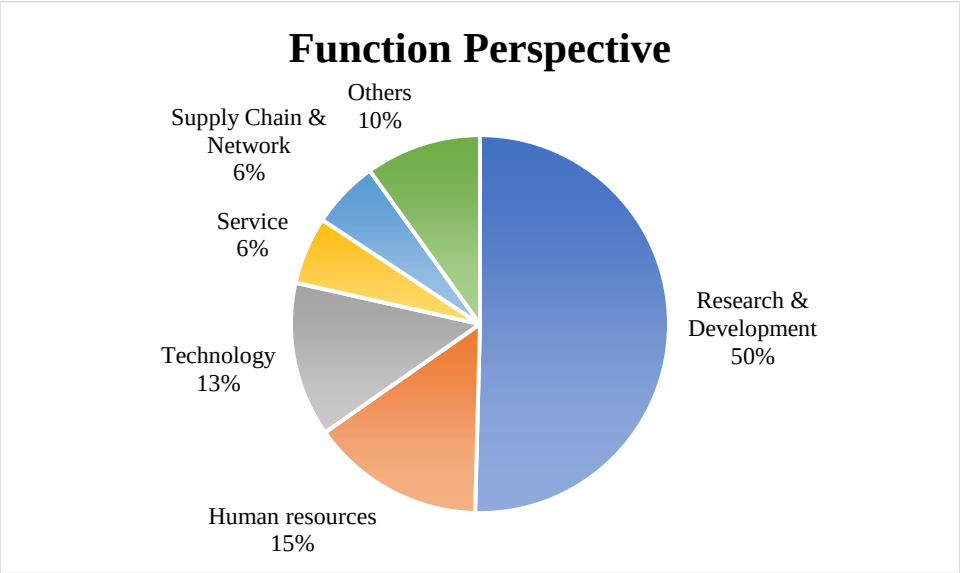


Figure 5 Reviews by function perspective

The other half of the reviews have very different and transversal perspectives: from human resources (15%) to technology (13%) to service or supply chain dynamics (6%), and other scattered perspectives less than 5%. This is a significant aspect since it

emphasises how KM is a transversal topic and there are many journals in the source classification to not have knowledge management as the primary topic of analysis. The bulk of the reviews (30.00%) concentrate on how KM is used in the private sectors, whether in a multinational enterprise, big company, SME, or in different types of organisations (Figure 6). When all the aspects (17.50%) were covered together, it was done by describing how KM fits differently into these dimensions. Reviews dealing with government organisations (8.33%) refer to the public administration and public health sectors, highlighting how high the demand for the huge volume of data to be managed in these areas is. Universities (1.67%) and start-ups (0.83%) are, on the other hand, the least considered in the sample. Interest in start-ups is relatively new compared to large enterprises or SMEs, so having chosen only secondary works could be a possible explanation of this low frequency. It looks astonishing to find very few reviews from the university's perspective considering that they are incredibly high knowledge creation environment and half of the reviews focus on the research and development perspectives. However, there are also many reviews focusing on no specific type of organisation (59.84%) highlighting how there is a strong theoretical debate around the topic.

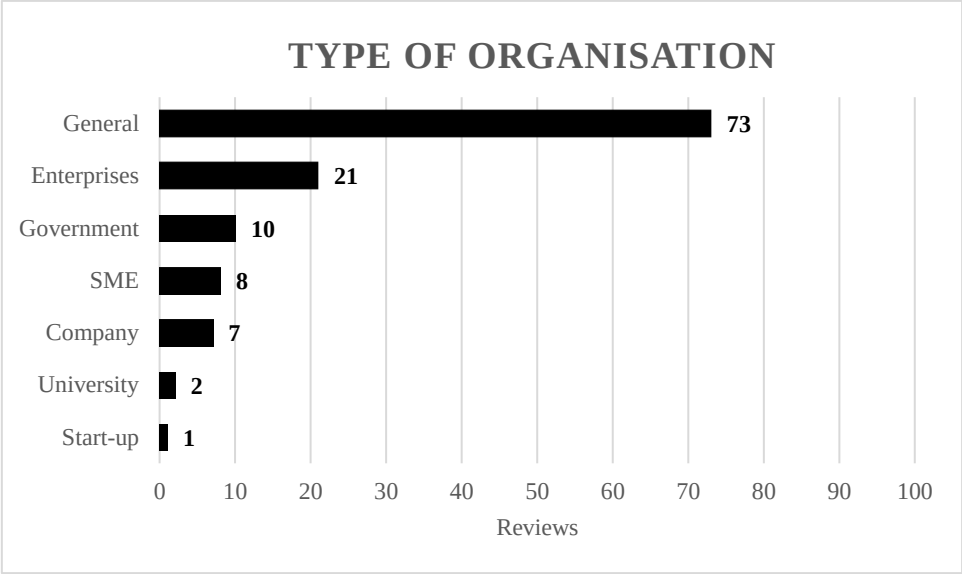


Figure 6 Reviews by type of organisation

In terms of knowledge dimensions, it has been observed that, globally, each review did not analyse a single aspect individually (ontologic/epistemological knowledge, knowledge as asset/flow, knowledge processes) but several themes have been addressed concurrently: in Figure 7 is shown the frequency of the main knowledge aspect analysed. The dimensions of knowledge creation and sharing have received the most attention. These two processes are critical in the generation of value and are frequently difficult to manage, precisely because they are very strongly linked to the sphere of tacit knowledge, which represents the third most discussed aspect: in all reviews containing these knowledge aspects, the need to create an environment that fosters the mutual trust, required to share individual knowledge, is emphasised (Durst, 2019; Iddy & Alon, 2019; Meier, 2011). On the other hand, there was still little attention on the macro-processes of absorptive/desorptive capacity. Even though Cohen & Levinthal (1990) and Zahra & George (2002) introduced these two processes at a superior level to the other six elementary processes, only in recent years have they started to interest researchers.

Particularly, desorptive capacity has never been mentioned. In fact, it has been observed and studied more recently than the other types of dimensions present, and thus, contrary to the inverse process of absorptive capacity, it has not yet been investigated in secondary sources. Another aspect not yet well analysed, but very relevant in the field of KM, is digital knowledge. Well embedded in the process perspective, it misses an epistemological discussion compared with the tacit and explicit nature of knowledge to clarify and classify this new type of knowledge.

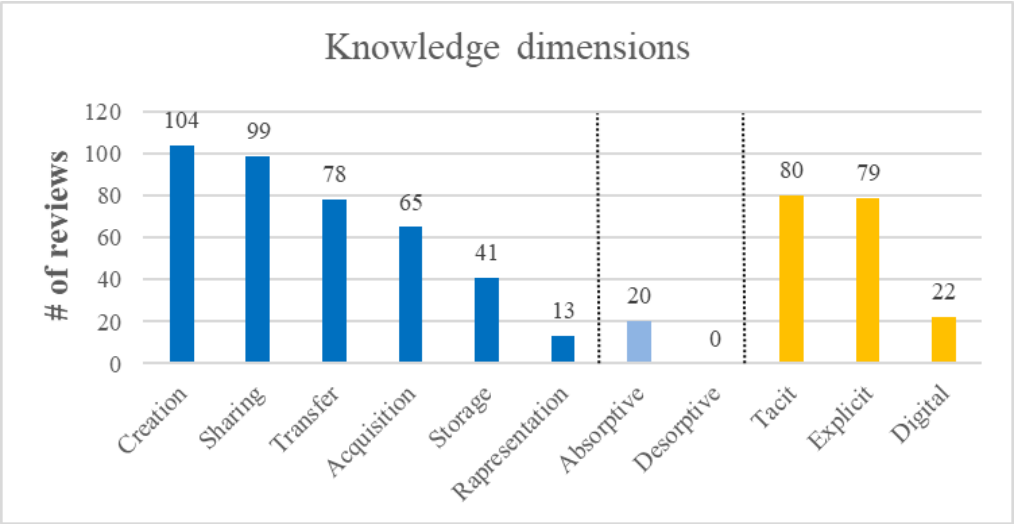


Figure 7 Knowledge dimensions

Another interesting viewpoint is related to thematic areas related to KM perspectives listed in Figure 8. The most frequently discussed topics were KM processes (i.e., creation, sharing, storing, transfer, acquisition, representation), particularly creation and sharing, as shown previously. Following there are organisational learning, organisational memory, and the decision-making process. In the sample, there are many reviews that consider multi-KM perspectives focusing on several or general sectors with the scope to create a

competitive advantage from the KM processes. This interest is reflected in the study of the processes and practices that feed this advantage, generating continuous learning and facilitating decision making and problem-solving (Chen & Chen, 2006; Floyde et al., 2013; Hendriks & Sousa, 2013; K. Wong et al., 2013); on the systems that can be implemented and on the tools that can be used to support these dynamics (Ayatollahi & Zeraatkar, 2020; Durst, 2019; Ramy et al., 2018; Y. Wang et al., 2018).

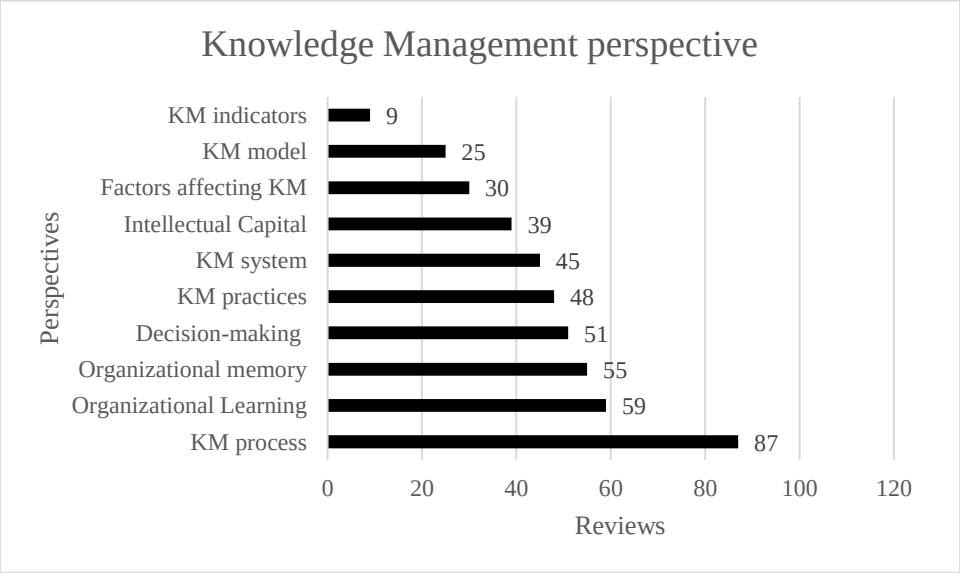


Figure 8 Knowledge management perspective

Most relevant reviews

This analysis shows how reviews are ranked according to the number of total citations or the weighted citations on their timespan. The first index, total citation score (TC), gives information about global popularity, while the second index, Yearly TC, gives information about its popularity along with the timespan (*Table 3*). By changing the criterion, the rank changes a little, but according to Strozzi et al. (2017), to find breakthrough papers

representing potentially impactful and promising scientific contributions, reviews must be ranked with the criterion of Average TC.

Table 3. Top ten ranking of the most cited papers

REVIEWS	TC	Yearly TC
ALAVI M, 2001, MIS QUART	4090	194.76
DURST S, 2012, J KNOWL MANAG	238	23.80
GAVIRIA-MARIN M, 2019, TECHNOL FORECAST SOC	65	21.67
GAVIRIA-MARIN M, 2018, J KNOWL MANAG	73	18.25
INKINEN H, 2016, J KNOWL MANAG	108	18.00
UREN V, 2006, J WEB SEMANT	255	15.94
RAGAB MAF, 2013, J KNOWL MANAG	117	13.00
CERCHIONE R, 2016, INT J PROD ECON	73	12.17
KHAN Z, 2017, J KNOWL MANAG	60	12.00
AL AHBABI SA, 2019, J KNOWL MANAG	36	12.00
CENTOBELLI P, 2017, SUSTAINABILITY-BASEL	54	10.80
MEIER M, 2011, INT J MANAG REV	117	10.64
BJORNSON FO, 2008, INFORM SOFTWARE TECH	148	10.57
MASSARO M, 2016, J KNOWL MANAG	63	10.55
CERCHIONE R, 2017, INT J INFORM MANAGE	51	10.25

The most relevant review in the research field considered is "*Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues*" by Alavi & Leidner (2001), a study that explores various dimensions of knowledge (ontological, epistemological, economic, and pragmatic) and different applications in the Information Technology field that can facilitate KM; the high quality and quantity of content have granted it a great fortune during the time with a very high citation power. Other reviews with a high number of global citations and a high citation rate over time include: "*Semantic Annotation for Knowledge Management: Requirements and A Survey of The State of The Art*" by Uren et al. (2006), which deals with information systems to support KM.

2.3.2. Evolution analysis

From a tertiary review perspective, analysing how the different gaps were born, managed, and eventually addressed is relevant. In Figure 9 there is the network of the main reviews considered in the research history of the KM. For the creation of the network, the CitNetExplorer software was used through the modularity function of Newman and Girvan (2004) joined with an intelligent local motion algorithm (Waltman & Van Eck, 2013) which allows to divide the sample considered into groups based on the citations, setting the limit of necessary citations to 2. It was possible to define the clusters found based on the common theme treated. Five years is the average period of publication of a review on the same topic, calculated as the average of the years of publication between two linked reviews.

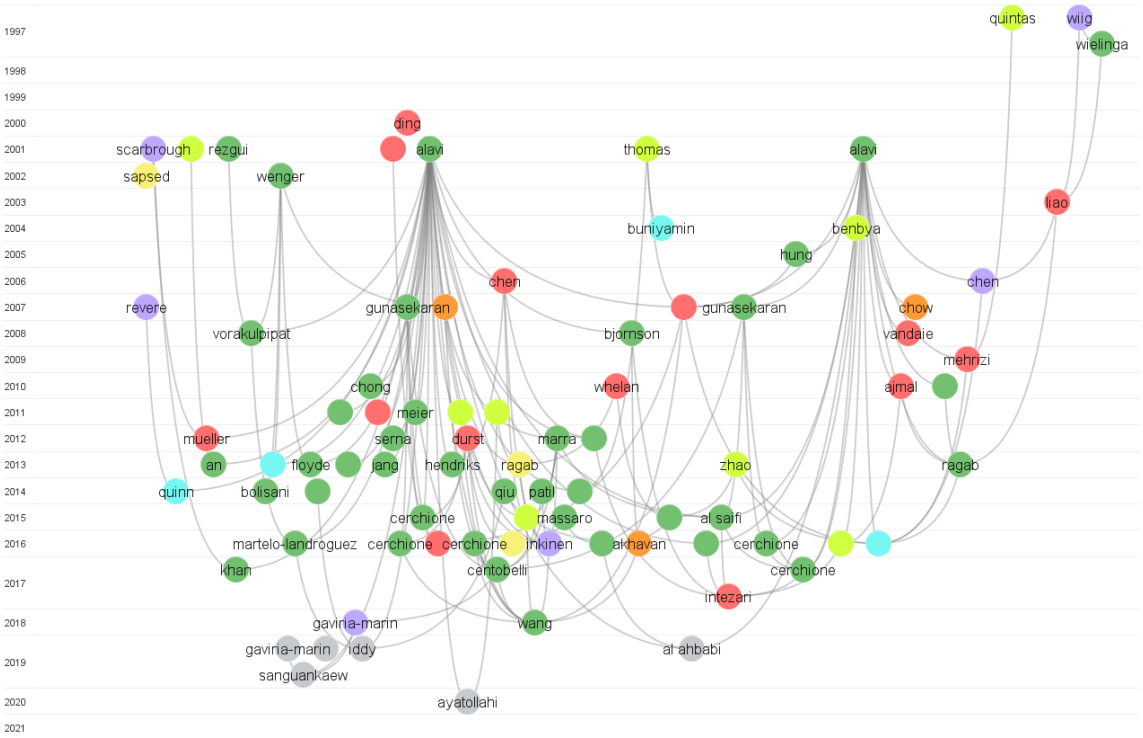


Figure 9 Evolution analysis

An analysis based on the content was conducted by categorising the publications based on their potential for application; each cluster comprises reviews that are citational strongly related to one another. We have found five main clusters:

- KM and information technologies (27 reviews);
- KM and SME (32 reviews);
- KM and performance indicators (7 reviews);
- KM and human resource management (30 reviews);
- KM and supply chain management (40 reviews).

KM and information technologies

This research line aims to understand how technology can support knowledge creation, dissemination, storage, and application, emphasising organisational learning and decision-making.

The contribution proposed by Alavi and Leidner (2001) is widely cited because it presents an exhaustive theoretical framework that begins with the definition of knowledge and extends to its processes, as explained through KM models. The authors introduce these theoretical concepts to explain why the organisation can be viewed as a knowledge system and to support the notion that information technology can be a valuable tool for facilitating the processes mentioned. Furthermore, the authors address the processes of knowledge creation, storage, transfer, and application, offering detailed recommendations on how technologies can support these processes and improve knowledge management in the workplace. Information technology promotes collaboration, communication, and coordination; as a result, it can facilitate knowledge creation by shortening the distances between members of an organisation and facilitating knowledge storage through tools such as databases, which not only provide storage space but also facilitate information retrieval among members (Alavi & Leidner, 2001; Floyde et al., 2013; Matayong & Mahmood, 2013; Quinn et al., 2014). As a result, knowledge transfer is facilitated because it is not limited to simple formal language, which is immediate and limited but makes knowledge accessible to those who are interested in it continuously. Information technology also accelerates knowledge acquisition processes and facilitates application and the necessary redesign process when integrating new knowledge (Alavi & Leidner, 2001; Floyde et al., 2013; Matayong & Mahmood, 2013; Quinn et al., 2014).

Floyde's (2013) work pays special attention to the usefulness that an adequate KM system can improve decision-making processes allowing people to store and make available the

appropriate knowledge at the right time. Specifically, the benefit of KM systems in managing health and safety workplace is studied, emphasising how such events are rarer in large corporations where there are funds to implement KM systems than SMEs. Self-learning via e-learning is a helpful solution for mitigating this vulnerability in the SME. E-learning uses multimedia and internet technologies to facilitate learning and provide easy access to multiple knowledge resources; thus, it can be used within SMEs because it adapts to the flexibility of their environments and can be integrated into daily work (Floyde et al., 2013). As a result, while technology can certainly aid in KM, it is not sufficient because one of the questions to consider is how it should be designed to accomplish this task (Bjornson & Dingsoyr, 2008; Weinreich & Groher, 2016).

There are works within the cluster whose intent is to answer this question, and special attention has been paid to developing software that meets the needs of the KM. Traditional software engineering research focuses on managing explicit knowledge based on knowledge codification, dissemination, acquisition, and communication (Bjornson & Dingsoyr, 2008). However, some needs necessitate more agile software capable of managing and disseminating even tacit knowledge, which has received less attention than the former (Bjornson & Dingsoyr, 2008). Weinreich & Groher (2016) categorise useful software for this purpose as software aimed at capturing knowledge, making it usable, conserving it over time, reusing it, and easily sharing it. There are numerous tools for capturing, using and reusing knowledge, but Weinreich & Groher (2016) believe that this does not solve the problem of capturing knowledge because it requires a greater effort that includes individual skills and competences. Similarly, simply having knowledge does not imply that it is then used correctly (Weinreich & Groher, 2016).

According to the study, software for big data analysis plays a critical role among software designed to manage knowledge (Ciampi et al., 2020; Z. Khan & Vorley, 2017). They differ from traditional databases since they are large in size, heterogeneous in nature, generated and processed quickly, and subject to unpredictable fluctuations over time (Ciampi et al., 2020). The big data text analytics tool allows converting large amounts of unstructured data into structured information, which is essential for KM purposes because it enables optimising decision-making processes, categorising data, and improving the relevance, quality, and timeliness of the acquired knowledge (Ciampi et al., 2020; Z. Khan & Vorley, 2017) .

It is important to emphasise that an adequate technology supporting KM does not guarantee an adequate use of the same knowledge because a lot depends on how the knowledge is perceived in the business context and how much interest there is in continuous learning and the acquisition of new knowledge on the part of its members: these tools must be combined with an organisational culture aimed at promoting sharing, with a lead role (Floyde et al., 2013; Quinn et al., 2014).

Particular attention to the KM system is present in the review of (Ragab & Arisha, 2013). The authors stressed the heterogeneity problem in KM systems studies: many frameworks for systems have been presented in the literature, with differences in definitions as well as the elements and processes involved in the systems themselves. Besides, the link between KM and the organisational innovation process has been amply demonstrated in the literature; however, the link between financial performance and knowledge management is unclear (Inkinen, 2016; Ragab & Arisha, 2013).

KM and SMEs

In this cluster, systematic reviews are the most commonly used methodology. The publications span 2007 to 2020 and primarily address the factors that promote and impede the spread of knowledge management within SMEs. The information and communication technologies used in this specific type of business and the KM impact on their performance are addressed in identifying these factors. Some of these studies highlight how it would be more exciting and fruitful for such research to be conducted with the substantial support of managers who could contribute with more empirical perspectives (Cerchione et al., 2015; Massaro et al., 2016).

SMEs have a very different approach to KM than large companies because it is common for only one person to make decisions (Cerchione et al., 2015; Durst, 2019; Edvardsson & Durst, 2014). Furthermore, they are distinguished by a lower economic resource presence than large companies, which may result in developing a knowledge management system that is not always adequate (Cerchione et al., 2015; Gunasekaran & Ngai, 2007). However, even if only partially implemented, the KM system can help SMEs succeed by influencing their performance (Cerchione et al., 2015; Durst & Edvardsson, 2012). Indeed, optimising KM can improve various types of performance within SMEs (Cerchione & Esposito, 2016): economic and financial performance, with an increase in sales and revenues or a decrease in costs; market performance, with an increase in market share, reputation, and relationships with customers; and technical performance, in terms of innovation, product quality, competence, and productivity.

Knowledge sharing and knowledge transfer are the epistemological dimensions that receive the most attention. Knowledge sharing can be facilitated within these companies

because an internal climate of mutual trust characterises them due to the smaller size of the workforce (Durst & Edvardsson, 2012; Massaro et al., 2016); knowledge transfer, on the other hand, may not be facilitated due to the high competition created between SMEs in the same sector (Durst & Edvardsson, 2012). As a consequence, the main technological solution SMEs adopt in supporting knowledge sharing and knowledge transfer is cloud computing (Saratchandra & Shrestha, 2022). However, this solution can also support other knowledge dimensions, boosting the enterprise's ability to better manage processes costs (Saratchandra & Shrestha, 2022).

Another relevant topic that all these reviews have in common is the study of factors influencing KM. The main barriers identified in the literature come from a wrong entrepreneurial culture and a lack of integration with existing processes and critical information protection (Cerchione et al., 2015; Durst & Edvardsson, 2012).

Three macro factors are identified as contributors to the success of KM: human and cultural factors (e.g., skills, training, education, trust, and collaboration), technological factors (e.g., the degree of computer applications, information systems, and infrastructure), and managerial factors (e.g., leadership style, organisational infrastructure, teamwork) (Cerchione et al., 2016).

Because humans primarily hold knowledge in SMEs, the factor used to manage it is primarily tacit KM techniques, and human-centred practices (e.g., formal meetings, seminars, communities of practice, sharing communities, informal networks, interactions with customers, interactions with suppliers, interactions with partners, training) (Cegarra Navarro et al., 2010; Choy Chong et al., 2011; Desouza & Awazu, 2006; Noblet & Simon, 2012).

Concerning the technologies used in SMEs, it is highlighted that the most used are databases, document management systems, emails, and newsletters, at the expense of more advanced technologies such as cloud computing and crowdsourcing. This is because one of the major barriers found in KM literature applied in SMEs is the scarcity of economic resources (Cerchione et al., 2015).

SMEs do not have explicit managerial regulations aimed at strategic KM as large corporations but instead deal with KM primarily at social relations, communication systems and digital technologies (Durst & Edvardsson, 2012).

KM and performance indicators

The third cluster, which runs from 2006 to 2018, is concerned with measuring KM performance. The studies and developments in this area are diverse since they are influenced by the views and fields of study of KM (Chen & Chen, 2006). There are two approaches to measuring KM performance: quantitative and qualitative (Chen & Chen, 2006; K. Wong et al., 2013): quantitative studies, using historical data and mathematical and statistical models, provide a measure that specifies the impact of KM in decision-making and performance; qualitative methods are more suitable for measuring tacit knowledge, focusing on the social aspects of KM, and studying how members perceive this discipline.

There are no techniques for measuring KM performance both internally and externally to the company because different realities use different techniques that produce different results that are difficult to compare (Kumar et al., 2021; Latilla et al., 2018). However,

the continuous improvement of the system can be equally stimulated by the improvement of individual internal performances (Chen & Chen, 2006; Lee & Wong, 2015).

Financial indicators, like Return on Investment (ROI), can be used to assess KM performance; however, the dynamic nature of knowledge has prompted scholars to focus on stochastic indicators, which allow for the capture of the volatility and variability of knowledge over time (Chen & Chen, 2006; Lee & Wong, 2015). Even if research has not yet provided macro-evidence operations, research and artificial intelligence are tools that allow dealing with the dynamic and stochastic environment associated with KM and can thus be used to optimise the KM performance measurement models (Lee & Wong, 2015; Wong et al., 2013).

KM and human resource management

The fourth cluster is more concerned with human resource management issues. Founded on the analysis of the review, it is clear how critical it is to create KM systems that are based on the concept of community, support social interactions, and discourage the individual dynamics that can operate as a barrier to KM (Rechberg & Syed, 2014; Thomas et al., 2001).

The cornerstone to a system that fosters socialising inside organisational contexts is storytelling: informal stories help to improve organisational learning, fuel the flow of knowledge throughout the organisation, and act as a glue across departments and levels. To develop this form of communication, a climate of mutual trust is required, favoured by small groups of people (Thomas et al., 2001). It is also essential to distinguish between individual appropriation and involvement in KM (Rechberg & Syed, 2014). The authors

define appropriation as a strategy employed by management to control knowledge and influence individual behaviour through norms; by participation, we mean a process of genuine involvement of individuals in debates and activities on knowledge management.

Because knowledge begins with the individual, it is necessary to start managing knowledge within the organisational environment starting from the individual enacting a proper organisational culture (Mahajan & Sharma, 2021). It can be difficult to persuade others to share but learning and creating new knowledge are equally hampered (Rechberg & Syed, 2014).

It is critical not to focus individual management on command and appropriation since they hinder an excellent atmosphere for sharing. Instead, focus on the needs and well-being of everyone, on what is necessary to establish conditions in which each member is comfortable in sharing knowledge (Rechberg & Syed, 2014). Organisational learning is more than just a collection of individual knowledge; it is dependent on individuals' intent to generate new knowledge: assigning a task to a person is not as functional as allowing people to choose the task they want to work on and utilising the characteristics of individuals to generate collaboration (Rechberg & Syed, 2014).

Wegner's study about the emergence of the concept of Communities of Practice (CoP) is a parallel research line. The concept of CoP can be viewed as both an unmanageable event that occurs spontaneously within organisations and as a strong KM tool that must be properly developed and managed (Bolisani & Scarso, 2014). It is a concept related to the organisation social aspects that has garnered significant attention in the literature and has been widely studied and contested, even if a single scheme that incorporates all considerations in this respect has still to be established. However, three organisational

macro-factors, that is top management, structure, and culture, look to be the main factors that can directly affect established CoPs within organisations (Aljuwaiber, 2016).

Another intriguing topic that has been examined is the role of leadership in KM processes. A good leader recognises a need for change and exerts influence for that change to occur, encouraging individuals to improve themselves and their work (Pellegrini et al., 2020). This clearly impacts KM because a competent leader who encourages sociability and knowledge exchange can be viewed as a vital tool in a KM system.

However, there is no univocal attitude to adopt in every situation and at every level, but the success of good leadership also depends on the social factors of the context in which it is applied and must be adapted (Pellegrini et al., 2020). Furthermore, leadership may undoubtedly benefit KM procedures, but if we want to encourage sharing at the individual or group level, it must be varied according to the objectives (Pellegrini et al., 2020).

KM and supply chain management

An intriguing trend is the analysis of knowledge within the supply chain or, more broadly, networks covered in the fifth cluster. The fundamental issue that publications in this field face are the transmission of tacit information within a network of different firms, as well as the acquisition of new knowledge that allows for a constant innovation process (Ding & Peters, 2000; Iddy & Alon, 2019; Meier, 2011; Weaven et al., 2014). This occurs because different information domains necessitate distinct KM strategies, and conflict between partners might arise, preventing adequate sharing (Ding & Peters, 2000; Meier, 2011). On the other hand, the diffusion of knowledge is critical for the success of collaborations (Iddy & Alon, 2019; Meier, 2011).

It is vital to building trusting connections between partner organisations by focusing on dispute resolution, stimulating learning, and ensuring that individuals of the company understand the value of sharing and receiving new knowledge from partners (Meier, 2011). It is also vital to foster a proactive culture geared at achieving common goals, encouraging collaboration and change techniques over time to promote consistent sharing (Meier, 2011). Processes of this type can lead to a more balanced distribution of knowledge and the possible creation of higher-level knowledge (Papa et al., 2020).

Initially, the literature concentrated on the relationship between the usage of KM in the supply chain and its performance on a dyadic relationship (Cerchione & Esposito, 2016). Following that, more emphasis was placed on the factors impacting the development of integrated KM throughout a network (del Rosario Perez-Salazar et al., 2017; Magni, Chierici, et al., 2021; Zerbino et al., 2018).

KM processes, and particularly knowledge sharing and transfer, are critical in ensuring process innovation, resource optimisation, and worker safety (Bhosale & Kant, 2016). Transfer and sharing can be encouraged by using appropriate support technologies but there is a dearth of simulations and fieldwork to evaluate its impacts or qualitative methodologies (del Rosario Perez-Salazar et al., 2019; Zerbino et al., 2018).

2.4 Conclusion, implication and future research

This tertiary literature review, conducted using WoS, provides a unique compendium of search directions to offer a comprehensive overview of the scientific debate about KM. The significant amount of primary and secondary studies published on KM issues in recent years justifies the need for this tertiary study. A novel tertiary methodology is suggested in this study by introducing a new step to conduct a dynamic analysis of literature gaps. This method represents an innovative and replicable solution for

evaluating and prioritising gaps identified in the literature. The document displays features and indexes based on citations, keywords, and collaborations. Many reviews have been published in the KM domain over the years, many of them in the last decade; however, a detailed analysis has not yet been performed to recognise how the research questions presented within the various reviews have evolved. This research contributes to the body of knowledge literature, thus providing a dynamic and comprehensive overview of the evolution of the literature on KM.

By implementing this tertiary study, it is provided concrete results on the state-of-art of KM literature. Notably, through the systematisation of published studies in the field, the analysis has recognised that KM processes can be defined as a form of total collaboration among the different components of an organisation, involving the creation and circulation of knowledge at multiple levels, incorporating it into products, services, and systems. In these terms, findings highlighted the main research streams in the KM field and identified a peculiar route to follow for future research. By aligning analysis with previous studies (Asrar-ul-Haq & Anwar, 2016; Bresciani et al., 2018; Del Giudice & Maggioni, 2014; Intezari et al., 2021), we argue that KM is an interdisciplinary theme, which need a well-structured analysis in terms of information technologies, strategies, and operations. So, the focus on developing a straight KM system means can create the possibility for an organisation to share and have access to information, as easily and quickly as possible, thus reducing costs and optimising the use of resources involved in business processes.

From the analysis, it can be concluded that KM research has gained increasing attention and emerged as a popular research field. A total of 122 reviews on KM were collected and analysed using mixed systematic, bibliometric, and network analyses. All the most cited articles have been published in the last twenty years. This is not surprising as the

field started to grow and develop massively in combination with technological and digital development as well as the globalisation of markets. *Journal of Knowledge Management*, with one-third of the reviews analysed, is the primary journal that researchers select for publication. Italy, UK, and USA are the most productive countries and with the highest review citation index. The analysis results highlight the main lines of research and clarify how these directions have evolved or stopped. More in detail, the results revealed five main research lines: KM and information technology, KM and SMEs, KM and performance indicators, KM and human resource management, and KM and supply chain management.

Starting from the results, this study provides a noteworthy contribution to the body of knowledge on KM while extending previous reviews (Asrar-ul-Haq & Anwar, 2016; Cerchione et al., 2020) in different ways. First, this study applies systematic, bibliometric, and network approaches to discover the most influential reviews, scholars, and countries based on the number of articles published and citations. Second, it proposes five associated review groups by theme and citation. Third, the study helps researchers highlight the most influential reviews. Fourth, the findings can help industries and governments identify key researchers working in the KM field for research projects. Fifth, publishers organising special and regular issues on the subject can invite prominent authors and research topics. Finally, this study offers a rigorous, up-to-date, and detailed outline of KM research. This study builds on and extends previous contributions by providing a broader framework to guide scholars approaching KM from different perspectives and more meaningful points of view. Scholars working on the KM domain can easily recognise researchers and countries who pay attention in KM areas to carry out joint research projects in this context.

Indeed, digital transformation has reshaped the KM process into the business. During the last years, several literature reviews have arisen to analyse the impact of digital technologies to KM strategies and systems (de Bem Machado et al., 2022; Ilvonen et al., 2018; Rêgo et al., 2022). The digital transformation process must be included in KM strategy analyses as it is vital to achieving and maintaining a competitive advantage for businesses over time (Rêgo et al., 2022). In addition, digital transformation impacts all five research streams found in this analysis (*KM and information technologies, KM and SME, KM and performance indicators, KM and human resource management, KM and supply chain management*), and it is the key to the irreversible contamination between external and internal environment in the KM process. Thus, KM aims to circulate corporate knowledge and store information, making it accessible when needed. To implement this type of activity, it is necessary to use knowledge management tools, which make it possible to import all know-how, search for information and obtain it when required (Ciampi et al., 2020).

2.4.1. Theoretical and managerial contributions

This study offers contributions for academic, managerial, practitioners and all the organisations involved in KM processes.

The primary implications of this tertiary literature analysis are theoretical. After much theoretical debate, the topic of tacit knowledge has not yet achieved the same results as the field of explicit knowledge; equally important, even though more recent, is the issue of knowledge exchanged in the digital environment. Furthermore, researchers should concentrate on the themes of absorptive/desorptive capacity, knowledge sharing, and knowledge transfer within SMEs, which, due to limited resources of these units of analysis, can have solutions and constraints that differ from those found in large

organisations. Besides, knowledge diffusion also looks to be further analysed to better understand the mechanism ruling the process of diffusion. There are certainly strong developing layers represented by knowledge hiding and leadership behaviours, as well as a human resource management system, from the perspective of a community of practices towards metaverse. Indeed, a lot of literature has evaluated the topic of knowledge hiding, providing an even broader framework in the theoretical context (Anand et al., 2021; Caputo et al., 2021; Siachou et al., 2021). Knowledge hiding often leads to the loss of intellectual capital due to employee turnover but especially to poor sedimentation of experience and expertise, which dictates some attention to the emerging knowledge spillover effect (Caputo et al., 2021). This consideration is significant and consistent in assessing the theory of employees' commitment to generating new knowledge.

Another theoretical implication of the study is referred to a new KM model that considers the possibilities of creating organisational knowledge using new technologies arising from the development of Industry 4.0. Specifically, technologies such as digital enablers trigger the former of an innovative business model, like responsible business model (Magni et al., 2022). By mapping the different key elements underlying the value creation process-connected through a theoretical lens, scholars can understand how the responsible business model reacts to any strategic and organisational changes in terms of performance, innovation, and KM processes.

From a managerial and practitioners' standpoint, it would be prudent to investigate how KM systems can influence economic, environmental, and social performance indicators. Indeed, the study supports managers with different perspectives that enable them to enjoy the benefits of KM in their processes and activities. Bibliometric information on KM reviews is of immense value to managers as it allows them to pinpoint the KM experience

globally. Moreover, findings provide determinate managerial implications related to the cultural dimension of the organisation. People, workers, and managers are the most critical element within KM processes since they are the holders of knowledge (Caputo et al., 2021; Magni, Scuotto, et al., 2021; Navarro et al., 2010; Thomas et al., 2001). Specifically, tacit knowledge resides in the experience and behaviours of the people who are part of the organisation. Therefore, the cultural dimension is of utmost importance: not only is it necessary to provide increasingly intuitive and user-friendly tools suitable for capturing, organising, and distributing information, but also to share the same corporate vision and be aligned on considering knowledge a key asset for generating value (Cerchione et al., 2016; Z. Khan & Vorley, 2017).

2.4.2. Future research directions and limitations of the study

The tertiary review approach enables us to identify potential future research ideas to continue or even resume the study on a specific line of research that is important for researchers or practitioners. Indeed, the perspective of tacit knowledge appears to be understudied and in need of additional theoretical and empirical research. While sharing tacit knowledge between people has been extensively studied, interaction with software remains a relatively unknown field. It would be appropriate for Weinreich and Groher (2016) to investigate how digital systems can support KM, disseminate tacit knowledge, support social dynamic storage, and share tacit knowledge. The issue of tacit knowledge is even more pressing in SMEs, where there is a scarcity of examples in the literature that group a whole set of tools and practices used to manage knowledge, particularly tacit knowledge (Cerchione et al., 2016, 2020).

Concerning storage and transfer processes, targeted studies would be appropriate to understand which are the main tools and practices that can facilitate these processes in

SMEs (Massaro et al., 2016; Scuotto et al., 2017) and how it may be possible to build documentation and coding system to build an organisational knowledge base, reduce the risk of tacit knowledge loss caused, for instance, by the withdrawal of members of the organisation (Durst & Edvardsson, 2012).

Another fascinating topic to be pursued to understand how a leadership behaviours and human resource management system can be created in a community of practices is a better and more complete analysis of the practices and processes that regulate leadership motivation (Pellegrini et al., 2020). Similarly, the analysis of why organisational actors disseminate or hide information in a network or supply chain appears to be a topic that needs to be developed further, possibly with an integrated analysis of which processes and tools can mediate between competitive advantage and mutual trust (Iddy & Alon, 2019; Meier, 2011).

The KM system represents a wide and interesting research area: many frameworks for systems have been presented in the literature, with differences in definitions as well as the elements and processes involved in the systems themselves (Ragab & Arisha, 2013). This is due to the studies' strong theoretical approach to the detriment of the empirical part, as well as differences discovered among organisational realities in which such systems can be implemented. According to Ragab & Arisha, (2013), future research could concentrate on precisely defining the standard elements of a KM system on which the subject studies are based. Another aspect that is still being researched is how KM can affect an organisation's economic and financial indicators: it would be necessary to examine the processes and links that govern this dependence (Inkinen, 2016).

According to Mariano & Awazu (2016), a better taxonomy of artifacts supporting KM is required, where an artifact can be represented by objects, tools, materials, technologies, nonhuman elements, or systems of tacit/explicit/digital knowledge management. Furthermore, it should be necessary to analyse the impact of managerial actions on using and exploiting artifacts using case studies and surveys (Mariano & Awazu, 2016). This aspect appears to be very urgent in light of the rapid digitalisation of the environment in which knowledge evolves. The knowledge paradox is inextricably linked to this aspect of KM performance. The paradox of knowledge management is an intriguing aspect that appears to have received little attention: the more knowledge is managed, the less knowledge is generated, and the greater the value of knowledge, the less the need to manage it (Hendriks & Sousa, 2013). By considering the challenge at the heart of intellectual capital studies' reflections on knowledge and, more broadly, on the measurement of performance related to KM, it is a failure to pay attention to how knowledge may or may not have value within the organisational context: treating knowledge as an asset or resource can lead to conceptual problems because, while knowledge is expandable, compressible, replaceable, transportable, and shareable, knowledge's true value lies in the future (Hendriks & Sousa, 2013).

In the Fifth industrial revolution, it would be necessary to comprehend how the technologies of Industry 5.0 can support and influence the human-centric processes related to the KM field and how reach an economic, environmental and social sustainability in the digital KM

Finally, despite the growing interest in KM for higher education institutions, research on the subject remains fragmented and broad (Quarchioni et al., 2020). Understanding the nature of KM within the university results crucial because universities, as a typical

knowledge generating organisation, are also evolving toward a more entrepreneurial configuration. Knowledge and digital technology perspectives, which are currently conspicuously absent from this research stream, could be another entry point for future studies (Secundo et al., 2019).

The limitations of this study are related to the revision method adopted. Some relevant studies may be excluded from our sample due to the exclusion criteria or filters adopted. This limitation can be related to the database used, the keywords chosen, the subject area and the inclusion/exclusion criteria found. Furthermore, another weakness is related to the prospect of analysis chosen to conduct the analysis of the content and derive the results.

3 Rethinking SECI model in light of the digital transition.

3.1 Objectives

Taking a cue from the results of the tertiary analysis conducted in the previous chapter, this chapter aims to conduct a bibliometric review of KM literature in the era of Industry 4.0 and Web 2.0 in order to provide a structured and comprehensive KM overview from a technological perspective in order to comprehend how the recent digital revolution has impacted the traditional method of managing knowledge. This analysis proposes:

- a review of the KM literature during the era of digital transformation;
- an insight into the research field through the use of performance analysis and network analysis;
- the identification of relevant research clusters.

Consequently, this chapter tends to formalise the actual knowledge creation model, bridging a research gap caused by the absence of a comprehensive overview of this research field where a formal taxonomy of actual knowledge creation practices is missing. The results of this analysis provide profound insights into contemporary debates, advancing the field of research on KM's contextual and multi-level phenomenon and indicating future research directions. This review is anticipated to make substantial contributions to the existing body of knowledge for the following reasons:

- it provides an overview of recent KM contributions confronting the digital transition;
- it provides relevant information for future researchers by summarising the most significant field of interest and the most prolific countries;
- it identifies research scopes and empirical issues adopted by this research stream.

3.2 Theoretical background and conceptual framework

3.2.1 Knowledge creation and digital transition

The concept of knowledge has been analysed in the body of literature from different perspectives concerning what it is, where it is embedded and how it can be classified.

Nonaka, (1994) suggested the SECI model for knowledge creation, taking these three classifications into account. The SECI model includes multiple knowledge conversion modes represented by four phases (socialisation, externalisation, combination, internalisation). According to this model, knowledge is transformed continuously through implicit and explicit forms, creating new knowledge (Nonaka et al., 2000; Nonaka & Konno, 1998).

Belisle (2006) introduces the concept of digital knowledge as a new independent dimension of knowledge due to the digital revolution. Digital knowledge can be rapidly processed by digital resources, dealing with a large and complex amount of data than the average human mind; so it is reasonable to conclude that digital knowledge processing is instantaneous compared to the time that a human mind might spend doing the same activity. According to the first knowledge perspective, digital knowledge is already codified as an accepted type of knowledge (Alavi & Leidner, 2001; Lin & Ha, 2015). Machines use digital knowledge as a commodity for both storage and transformation; they can also support in decision-making since computer processors can process relevant data to provide qualitative and specific information (Kroenke, 2018; Pérez-González et al., 2017). Regarding the second perspective, it is possible to consider digital knowledge to be autonomous because it is possible to find this type of knowledge in various forms, with the ability to not consume itself both in using and in transmitting, even though the

ability to use it is restricted (Dalkir, 2013). One critical aspect of this perspective is that digital knowledge exists primarily outside of company boundaries; as a result of this characteristic, it is a crucial KM process to bring this resource within, scan it, and secure it (Cripps et al., 2020; Fakhar Manesh et al., 2021; Townsend et al., 2018). Concerning the third perspective, several contributions suggest that digital knowledge can be classified into different ontological dimensions, that is, individual, community, organisational, inter-organisational (Cripps et al., 2020; D'Andrea et al., 2019; Fakhar Manesh et al., 2021; Kroenke, 2018). Considering the epistemological dimension, machines interact using bit-based language that is very enigmatic and difficult to understand by the human mind. As a result, digital knowledge is codified as explicit knowledge for interaction with natural language. However, it is impossible to assume that digital knowledge is a specific explicit knowledge since it cannot be accessed or used without the knowledge owner (Aleksander, 2017; Belisle, 2006). Similarly, it is challenging to describe digital knowledge as a distinct tacit knowledge since computers can not perceive data with conscience, self-awareness, and intentionality (Aleksander, 2017; Rainey, 2017).

In recent decades, the subject of KM had become increasingly important in discussions about organisational management since a significant change in theoretical paradigms occurred when Industry 4.0 innovations fully transformed the industrial environment (de Carvalho et al., 2018; Tuptuk & Hailes, 2018). If previous technological revolutions often changed the environment by keeping humans at the centre of decision-making and considering machines as operational instruments, in this current revolution, both humans and machines are at the centre of decision-making processes: machines are no longer simply data collectors but can contextualise data and make decisions by reproducing

human cognitive processes (Li et al., 2018; Minh Dang et al., 2019; Vanitha et al., 2020). Furthermore, people are constantly connected via mobile devices and social media platforms, changing how people communicate (Schwarzmüller et al., 2018). As a result, the SECI model for knowledge creation is no longer describing the process thoroughly. New channels for knowledge development have opened up, and traditional human interactions must now cope with human-machine and machine-machine interactions (de Bem Machado et al., 2022). From an ontological perspective, knowledge interaction occurs in two distinct spaces: the human space (e.g., individual, community, organisation, inter-organisation) and the digital knowledge space. This means that knowledge interaction involves several interactive experiences that are no longer inalienable in the knowledge creation model. Figure 10 depicts a formalisation of these two knowledge spaces.

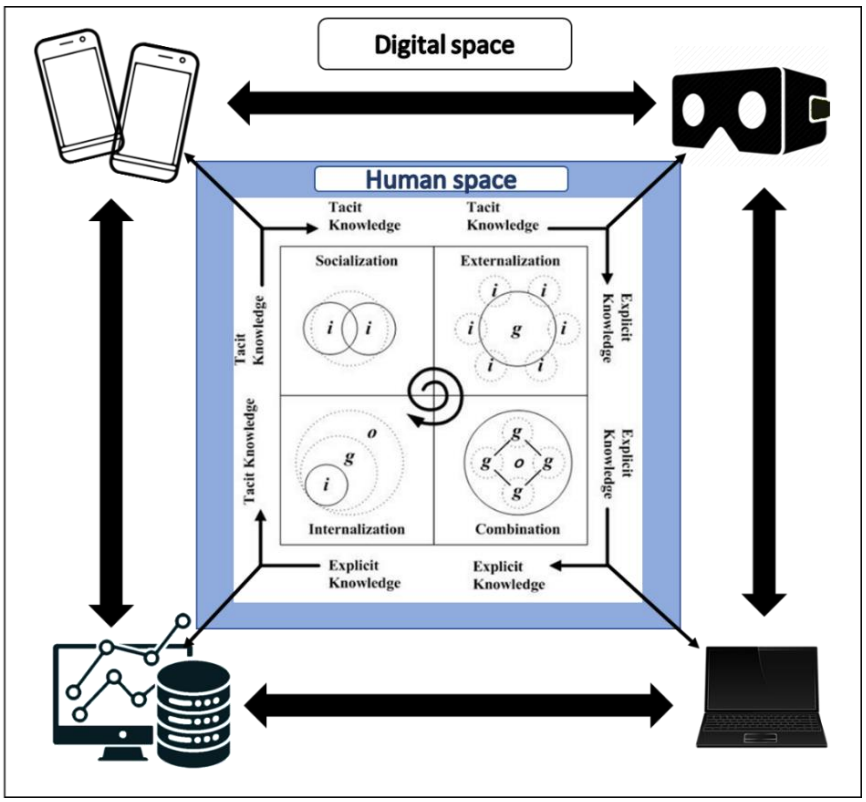


Figure 10 SECI model in the digital space

The contemporary knowledge environment alters the spatial and temporal dimensions of knowledge creation: people connect when they are not physically close and at different times, significantly changing the time gaps associated with information sharing. However, while considering the significance of this digital transition in the field of KM is theoretically simple, evaluating its impacts is more difficult. Despite the interest in digital business transformation, implementing digital solutions and measuring organisational performance remains highly difficult (Lehrer et al., 2018).

3.2.2 Knowledge conversion modes

Explicit - Digital knowledge

Numerous activities that were previously exclusively carried out in person have been shifted online due to digital advancements; owing to a simple remote link, many people from all over the world may join training courses, meetings, presentations, and educational activities (Aparicio et al., 2019). Bringing explicit knowledge to the digital realm is a stimulus for creative processes; many firms use social media, particularly crowdsourcing, to network with their organisations and customers (Maravilhas & Martins, 2019). The broader the network of people who can experience, the greater the opportunity of integrating this experience, and hence the greater the possibility of developing new knowledge and competitiveness (Almeida et al., 2011; Rodriguez & Martius, 2013).

Tacit - Digital knowledge

The problem of turning tacit knowledge into digital knowledge and vice versa is a controversial issue, with no clear consensus (Maravilhas & Martins, 2019). There are two

points of view. The first one contends that because tacit knowledge pervades human thoughts, behaviours, and judgments, it is inaccessible to AI (Johannessen et al., 2001). Instead, the second school of thought contends that knowledge has varying degrees of tacitness and that it is thus conceivable to progress from absolutely explicit information (which can be easily changed and conveyed digitally) to purely tacit knowledge (Chennamaneni & Teng, 2011). The efficacy of digitalisation reduces as the degree of tacitness grows, and hence the amount of tacit information sent decreases (Khan & Jones, 2011). Several scientific investigations have revealed that AI, IoTs, and augmented/virtual reality (AVR) technologies have advanced to the point where they can precisely imitate human cognitive and emotional states (Brown & Sandholm, 2019). Communication systems, multimedia sharing systems and Web 2.0 tools are the key IT tools useful in transmitting tacit knowledge (Khan & Jones, 2011; Panahi et al., 2016). It is possible to convert digital knowledge into tacit knowledge by demonstrating or imitating activities or processes represented via video, audio, or text in order to unintentionally activate abilities required for the performance of that particular process or activity (Hildrum, 2009; Panahi et al., 2016).

Digital - Digital knowledge

Nonaka hypothesised the existence of a digital dimension of knowledge (Nonaka et al., 2000; Nonaka & Toyama, 2015), however, it was never possible to view it as a separate dimension until nowadays. The digital world has established itself as an autonomous environment where information can flow due to cutting-edge technologies. The sensors acquire data and send it to the cloud, increasing the amount of data on the network and resulting in ever-expanding IoTs (Dragicevic et al., 2019). Nonetheless, certain AI technologies can think critically and contextualise information, reflect, plan, and learn

from acquired knowledge (Parisi et al., 2019). Both explicit and tacit knowledge can be carried through the digital dimension. This has enabled the development of ontologies and rules for deconstructing and rebuilding natural language allowing other devices to interact with other ones using these ontologies and give back other knowledge intelligible by human intelligence (Parisi et al., 2019; Sikos, 2017).

3.2.3 Towards a digital knowledge-creating company framework

The concept of digital transformation extends beyond fundamental attempts to increase the performance of IT systems and implement underlying hardware (Puthiyamadam, 2017). The concept of digital transformation is founded on the premise that an organisation conducts its business by utilising cutting-edge digital technologies (Hess et al., 2016). The use of these trailblazing digital technologies has the potential to fundamentally alter the way people think about business, improving financial and market efficiency while also promoting innovativeness (Hess et al., 2016; Nambisan, 2017). Digitalised organisations can access and process information more quickly than traditional ones, resulting in operational, financial, and market benefits (Townsend et al., 2018). More specifically, numerous digital technologies serve one or more knowledge creation processes. For example, the IoTs represents a real-world twin where data and information flow from one device to another, and these devices serve as the interface between the real and digital worlds (Xue et al., 2013). These large amounts of information are frequently structured as BDA, and AI systems analyse them to produce more accurate data and important information for decision-making (Grover et al., 2018; Lu et al., 2015; Metaxiotis et al., 2002).

3.3 Material and methods

The bibliometric review methodology was chosen to investigate the research field. Performance analysis and science mapping are bibliometric techniques that can help to outline intricate knowledge patterns of a research field, investigate their properties employing statistical and mathematical methods, and monitor the evolution field to identify how authors, themes, and contributions are related (Cobo et al., 2014; Mora et al., 2019). Citation analysis is one of the most common techniques used in the bibliometric analysis: higher is the number of citations received by a paper, and higher is the relevance of that paper in the body of literature (Aria & Cuccurullo, 2017). Citation analysis can use two main techniques: bibliographic coupling and co-citation analysis (Centobelli et al., 2021; Yan & Ding, 2012). A bibliographic coupling connection is established when two documents cite the same third document and help detect the actual connections into research groups, whereas a co-citation connection is established when the same third document cites two documents. and helps see-through shifts in theories and paradigms over time (Aria & Cuccurullo, 2017). Like in the tertiary review, also bibliometric review has the same methodological conceptual schema reported in Figure 1, which consists of three main steps:

- Material collection phase: a detailed discussion about the academic database and keywords used to collect papers.
- Material pre-processing: the pre-processing operations to clean data and remove spelling mistakes from the database.
- Results analysis: the results of performance analysis and network analysis.

As for the material collection phase, papers have been collected from Scopus database. This database represents a reliable and high-quality data source for literature analysis (Johnsen et al., 2017).

The search string used is:

TITLE-ABS-KEY ((("blockchain" OR "block chain*") OR ("iot*" OR "internet of thing*") OR ("Artificial Intelligence" OR "AI" OR "machine learning" OR "deep learning") OR ("social media" OR "social network*" OR "social platform*" OR "social technolog*") OR ("Industry 4.0" OR "I4.0") AND "knowledge" AND ("tacit" OR "explicit" OR "digital" OR "socialization" OR "externalization" OR "combination" OR "internalization")).*

In this way, it is possible to obtain all the papers that explicitly deal with the topic under investigation. The asterisk has been used to include a wide range of results. The data collection phase has been conducted in January 2021, papers from 1974 to nowadays are in the results list, but in the final sample only papers in English published between 1985 and 2021 have been considered; papers before 1985 do not match the research topic, and papers related to 2021 do not fully characterise the researchers' interest for the year. Finally, to ensure the quality of review analysis, conference proceedings and book chapters were excluded, and in the final sample only papers and reviews published in peer-reviewed journals have been included (Newbert, 2007). At the end of this phase, the total number of papers considered for the following steps is 7,500 (6,929 articles and 571 reviews).

As for the material pre-processing phase, the bibliometric database was submitted to a pre-processing process to avoid duplications for spelling mistakes or contractions (e.g.,

network/networks, IoT/IoTs/Internet-of-Things; knowledge-based system/knowledge-based systems).

3.4 Results and Discussion

3.4.1 Descriptive analysis results

This section presents the descriptive and content analysis findings. In Figure 11, it has been shown how papers considered in the study are distributed. The earliest contributions focused on the idea of adopting AI to support knowledge management processes (Russell & Norvig, 2003). The study of AI restarted in the 1990s due to technological advancements in the integrated circuit industry. Meanwhile, the IoTs began to be researched as a technology capable of returning critical information, becoming a valuable KM resource. The number of papers published has increased dramatically since the turn of the century. Between 2003 and 2010, the IoT emerged as one of the most spread digital capabilities for managing knowledge. Furthermore, in the aftermath of a hyper-connected environment, AI technology, machine learning and deep learning techniques, were adopted in the KM domain. Since 2008, blockchain technology has become powerful technological support in the storage and transmission of knowledge, ensuring the capability to validate the reliability of the information in a trusted, traceable, and transparent way.

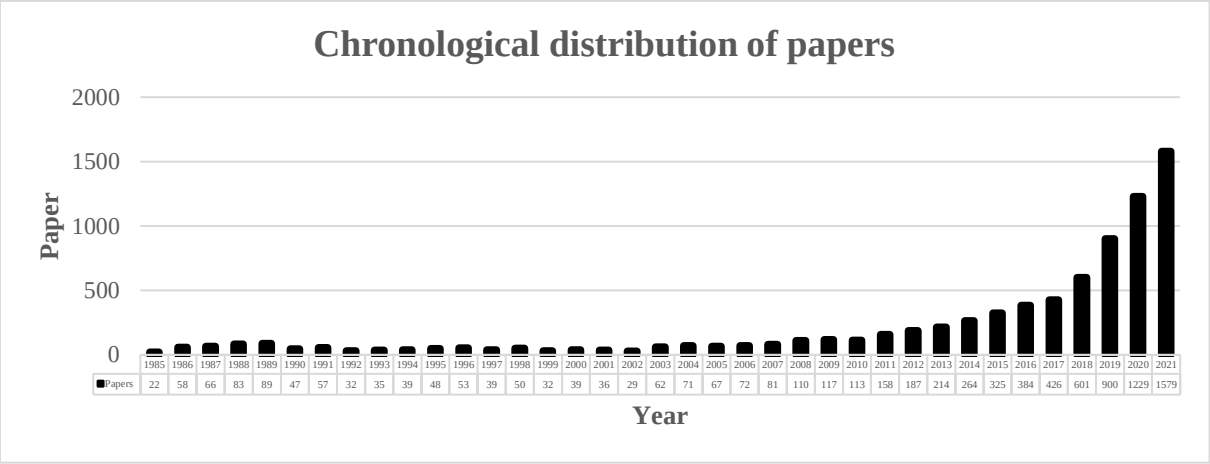


Figure 11Chronological distribution of papers

From all the 92 countries involved in this field, three countries have published a consistent amount of the total papers published: the USA (25.4%) followed by United Kingdom (13.3%) and China (12.8%).

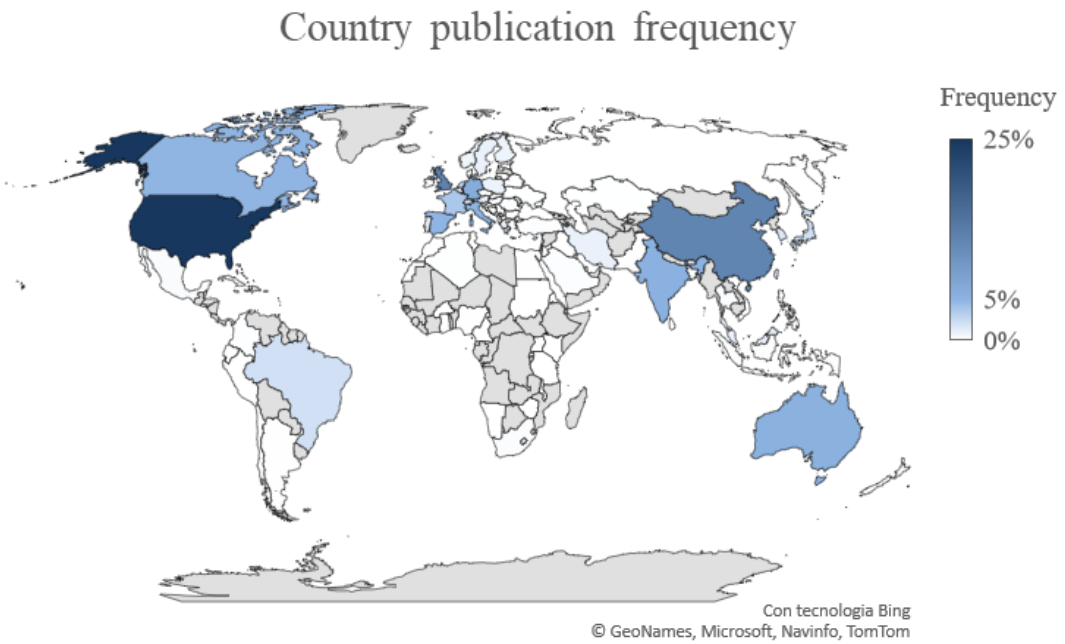


Figure 12 Geographical publication frequency

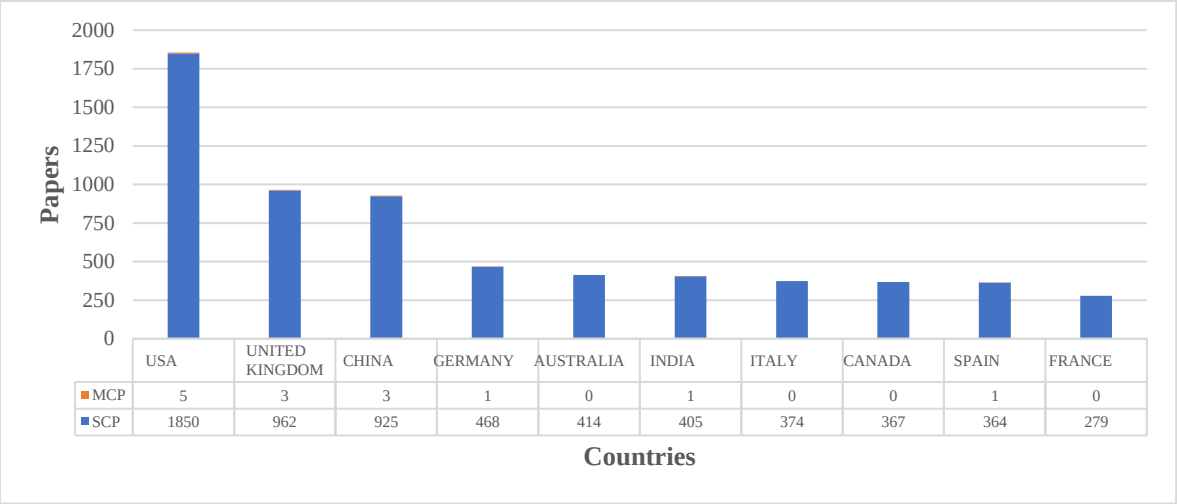


Figure 13 Top10 country citation

Considering the single country production (SCP), the three main countries remain the same; this result highlights that technological innovation in KM is a core research business for the most productive countries. Figure shows the geographical distribution and the Figure differences between the top10 countries' publications.

Focusing on the author's keywords, Table 4 highlights that the leading technologies used to support KM process belong to the AI domain (i.e., AI, Pattern Recognition, Machine Learning, Artificial Neural Network, Deep Learning) with a presence in 10.73% of papers. This predominance over other technologies seems justified because AI technologies entered the field of KM much earlier than the other two: IoT (3.18% of papers) entered during the second part of the ’90s, while blockchain (0.32% of papers) quite recently. The central phase in the KM process is the creation phase, with the knowledge discovery, acquisition, and extraction present in 1.50% of papers.

Table 4 Most used author's keywords

	Author Keywords (DE)	**Articles**	**Frequency**
1	AI technologies	698	10.73%
2	SOCIAL MEDIA	482	7.41%
3	IoTs + Internet	207	3.18%
4	KNOWLEDGE MANAGEMENT/ENGINEERING	125	1.92%
5	KNOWLEDGE Discovery + Acquisition + Extraction	98	1.50%
6	EXPERT SYSTEM	90	1.38%
7	DATA MINING	74	1.14%
8	DECISION SUPPORT SYSTEM	62	0.96%
9	KNOWLEDGE REPRESENTATION	61	0.94%
10	LEARNING	61	0.94%
11	EXTREME LEARNING MACHINE	56	0.86%
12	KNOWLEDGE SHARING	52	0.80%
13	ONTOLOGY	49	0.76%
14	KNOWLEDGE	48	0.74%
15	KNOWLEDGE BASED SYSTEM	43	0.66%

16	SOCIAL CAPITAL	34	0.52%
17	FUZZY LOGIC	33	0.50%
18	NETWORK	33	0.50%
19	BDA	31	0.48%
20	INNOVATION	30	0.46%

3.4.2 Network analysis

Figure reports the results of the co-occurrence analysis with the author's keywords. Ignoring isolated nodes, the author's keywords plotted are 720.

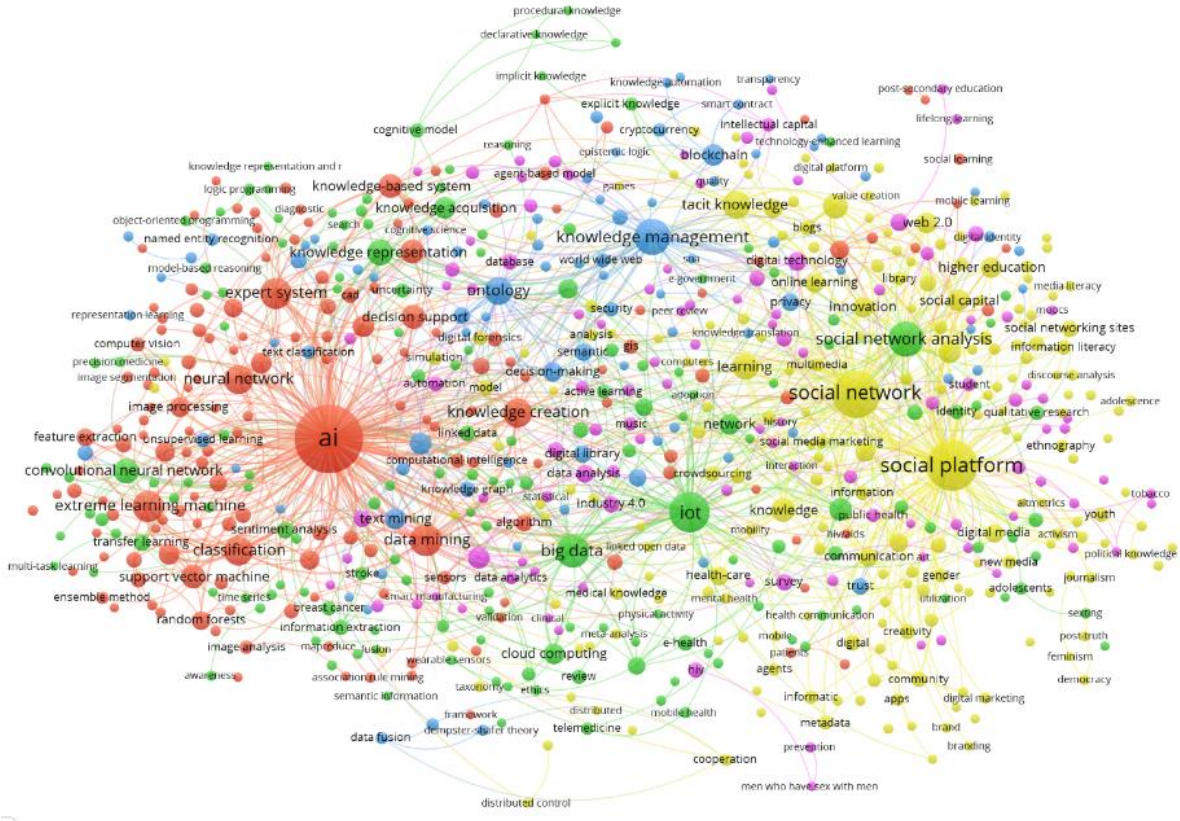


Figure 14 Keyword Co-occurrences

Four different macro clusters emerge from the results analysis (Figure):

Cluster 1: Knowledge webinarisation (yellow cluster with 208 keywords)

Cluster 2: Knowledge informalisation (pink cluster with 107 keywords)

Cluster 3: Knowledge systematisation (dark blue cluster with 85 keywords)

Cluster 4: Knowledge explicitation (red cluster with 160 keywords)

Cluster 5: Knowledge digitalisation (green cluster with 160 keywords)

In the next subsections, we conduct a content analysis of these clusters and discuss how extant literature investigated the relationship between digital transition and knowledge creation processes.

3.4.2.1 Knowledge webinarisation

According to the body of literature, numerous digital systems enable knowledge webinarisation. Webinarisation is the process of transforming explicit knowledge into digital knowledge. The papers in this cluster are concerned with the social media environment, which has been enabled by the extensive availability of digital services and capabilities (Fakhar Manesh et al., 2021). In the digital era, social media platforms (e.g., Facebook, Twitter, Instagram, LinkedIn, and Pinterest) may allow global diffusion and visibility of knowledge (Järvi et al., 2018; Jeyanthi et al., 2020). Social media facilitates knowledge exchange among people's networks (Kroenke, 2018). Over the last twenty-five years, the internet has undeniably revolutionised interactions, transformed communications, and enabled contact between persons or organisations (Cripps et al., 2020; Y. Wang et al., 2018). Social media's diffusion capacity makes them relevant for

KM, particularly in transforming explicit knowledge into digital knowledge (Assaad & Gómez, 2011; Bele et al., 2018). Because of the large volume of knowledge moving through the various network platforms, they are tempting organisations seeking to learn from users, competitors, and stakeholders (Pérez-González et al., 2017). For the organisation, crowd-based knowledge is more responsive than ever before, allowing them to have both great control and a high degree of openness in their crowdsourcing activities. Agile knowledge has significant organisational benefits (Cripps et al., 2020; D'Andrea et al., 2019): it enables them to create products and services that are more appealing to current or potential clients, especially in the business-to-business setting, as well as to increase their degree of innovation and competitive sustainability. Social platforms are a source of useful information on business market innovation and the exchange of both high quality and relevant information (Cripps et al., 2020; D'Andrea et al., 2019).

Similarly, Quinton & Wilson (2016) describe how using the LinkedIn platform can boost the development and performance of business connections. The education sector is an important unit of analysis in knowledge webiniarisation. Many schools, institutions, and organisations have addressed teaching and collaboration in ways that are no longer face-to-face and limited to the classroom. They enrol in online courses that are available to the public, such as massive open online courses (MOOCs) (Brahimi & Sarirete, 2015). This strategy allows learning sharing with a larger range of individuals who differ in sex, gender, age, and origin, hence broadening the network through which explicit knowledge can flow and be updated in the form of digital knowledge. In recent years, a slew of new platforms has developed: Coursera and Audacity in the United States, FutureLearn, Iversity, and FUN in Europe (Brahimi & Sarirete, 2015).

3.4.2.2 Knowledge informalisation

According to the literature, many digital technologies allow for the informalization of knowledge. The process of converting digital knowledge into tacit knowledge is informalisation. This cluster addresses the issue of digital knowledge transfer to tacit knowledge through the use of collaborative systems and digital communication. Hidden tacit knowledge coexists with digital knowledge when using social media. Browsing, organising, and using digital knowledge sources allows us to link instinctively with mental patterns and concepts that begin to form tacit knowledge (Panahi et al., 2016). Several studies have found that using social media allows for the transfer of both digital and tacit components (Atrash et al., 2015; Buunk et al., 2019; Panahi et al., 2016). The social dimension enhances digital knowledge exchange by allowing people and experts to communicate easily and acting as an amplifier making tacit knowledge available to a wider audience (Belbaly Aissa et al., 2022; Buunk et al., 2019). Grum & Gronau (2017), supported by AVR and cyber-phisical system, created a system able to transfer previously assimilated components of digital knowledge into tacit knowledge.

3.4.2.3 Knowledge systematisation

Previous research demonstrated that it is possible to systematise knowledge using various digital tools that turn tacit knowledge into digital knowledge, such as text mining, natural language processing (NLP), knowledge-base, digital library, and ontology. Although researchers prefer to deal with explicit knowledge rather than tacit knowledge, knowledge systematisation results crucial in several sectors (i.e., education, research, healthcare, security). So numerous attempts have been made in the literature to digitalise tacit knowledge in order to keep it available within the company over time, using text mining and NLP, computer ontologies systems capable of generating human behaviour (Atrash et al., 2015). Using the ontologies resulting from the text mining and processing them

with NLP and AI technologies it is possible to achieve human behavioural predictions: for example, it is feasible to predict unlawful or terroristic web actions, customer turnover in order to reduce apparent attrition, or extract information on drug side effects given by electronic medical record clinical narratives (Sohn et al., 2011; Zanasi, 2009). Tacit information is not limited to a single person or organisation. It is also feasible to share it with other individuals or organisations by building a knowledge-based network (Li et al., 2018). When a system is opened up to knowledge synthesised by other entities, the issue of knowledge quality arises, notably in terms of trust and traceability. Li et al. (2018) presented a blockchain-based knowledge exchange paradigm for different enterprises in the supply chain. Each company contributes only a piece of its primary business to the decentralised database. As a result, blockchain technology enables all firms to access this accumulated knowledge, with the trust of each contribution validated by blockchain protocols that also give traceability information. This system is helpful in the context of the ontological construction of tacit knowledge since it allows businesses to reduce the time spent seeking to make a broader knowledge contribution (Atrash et al., 2015; Li et al., 2018).

3.4.2.4 Knowledge explicitation

Explicitation is the process of converting digital knowledge into explicit knowledge. The literature demonstrates that knowledge explicitation is possible through various digital solutions. After inspecting the cluster's nodes, it was discovered that AI-related technologies enable the main knowledge conversion operations. Based on data collection or previously acquired behaviour, these solutions can forecast the system's behaviour. As a result, it is acceptable to believe that this cluster studies knowledge translation from a digital form to an explicit form. Approaches are different, but at the end of the process,

numerical findings are transformed into an explicit form using a human behaviour database (Delen et al., 2013). The artificial neural network is one of the most widely utilised techniques for simulating human behaviour, learning, and reworking various cognitive patterns. These non-linear algorithms are particularly versatile since they can operate with inadequate or imprecise data and predict outcomes with a good precision (Delen et al., 2013). AI technologies will always return a different cognitive level and in a systemic and exact form, regardless of the data source; as a result, it is plausible to infer that these technologies have a high learning power, in explicit knowledge generation and representation (Delen et al., 2013; Lu et al., 2015; Metaxiotis et al., 2002). Within an organisation, AI technologies interfere in numerous functions such as supply chain, maintenance or quality domains (Loureiro et al., 2021), but marketing is the function that leverages it the most (Grover et al., 2018; Zhou et al., 2018). Organisations have information from external sources in the form of BDA, which can return explicit knowledge on consumer shopping online behaviour and service qualities they prefer based on the basket of desired products during the transaction (Grover et al., 2018). Likewise, competitors' sales and production strategies might be defined (He et al., 2017). AI systems conduct data mining and generate predictions based on ontologies that have been established over time (Loureiro et al., 2021). The explicit knowledge that decision-makers can report is related to the current market condition and present and future situations based on previous behaviour (Bekkouche et al., 2017; Georgiev & Georgiev, 2018; Grover et al., 2018). In agriculture, these technologies are used to estimate which fertiliser should be stored in order to assist future soil cultivation (R. Sharma et al., 2020). Another use of these technologies in the tourism sector is to estimate which places will

be more appealing in the next seasons and what services will make them more popular (He et al., 2017; Garg et al., 2019).

3.4.2.5 Knowledge digitalisation

Digitalisation entails the merge and growth of digital knowledge from a different origin. There are numerous digital options for converting digital into digital knowledge; yet, only a few papers address this subject, and none of them seems to emphasise the importance of one solution over the others. Digitalisation comprises all operations involving digital knowledge exchange between machine entities; consequently, knowledge remains digital throughout the numerous sharing processes. The IoTs are important to spreading this mode of knowledge: individuals work, communicate with others, and manage their personal lives through equipment that IoT connects (Vanitha et al., 2020). Simultaneously, cloud has risen, and new customisable services are being supplied remotely to various network users; with the flexibility to customise these services, users' experiences can be improved (Minh Dang et al., 2019). On the other hand, users provide personal information about their lifestyle and wants by personalising the requested service (Minh Dang et al., 2019). This has resulted in the rapid development of virtual digital knowledge storage, which needs organised BDA techniques for their management and coding due to the vast volume and variety of information contained within (Bibri, 2018; Gil et al., 2016). Given that the first massive flow of digital knowledge comes through social media networks and social media platforms, social network analysis (SNA) may be one of the most valuable methods for exploring this topic. Using SNA approaches, it is feasible to comprehend a group's needs and desires and how they develop over time. It is crucial to be able to produce a historical dataset of this type since it is feasible to gather information on current trends in a given geographical region and ML can summarise knowledge on future

developments (de Laat et al., 2007; Xu et al., 2014). Predictions about the preferred political candidate during the 2007 Democratic Presidential election campaign were conceivable, as were predictions about the most in-demand occupations in America in 2014, based on the LinkedIn database and user activity on this platform (de Laat et al., 2007; Xu et al., 2014). However, SNA is more than just a social tool; the combination of SNA with cloud systems allows companies to improve the information acquisition process, with significant implications in every business area and on operational and financial indicators (Castagna et al., 2020; Cegielski et al., 2012). Environmental and inter-organisational uncertainties are reduced, and information flows are better managed and well-integrated with previous classic knowledge management systems; however, this effect is minor for SMEs because they are quite often unable to anticipate the technological changes that affect KM (Castagna et al., 2020; Cegielski et al., 2012). It is feasible to construct an open and decentralised manufacturing ecosystem by integrating IoT cloud computing technologies with AI analytical capabilities and blockchain capabilities to certify the information travelling between various devices (Li et al., 2018).

3.4.3 Conceptualisation of WISED framework

This section develops a conceptual model to summarise and systematise bibliometric analysis findings (Figure). The idea of such a model is interesting from several points of view. Although KM processes in this new era of digital transition and the fourth industrial revolution have been analysed in different management literature areas, they have generally been investigated as separate domains. Bibliometric analysis can link the various research conducted on specific topics and create a network in which the main topic areas are highlighted. In this way, it was possible to highlight three fundamental aspects.

The first aspect is that digital technologies have high potential and allow managing vast amounts of data and processing them for transformation into valuable knowledge resources for decision-making.

The second aspect is that these technologies do not remain within the company boundaries and require the integration of all the actors involved in the digital space.

Finally, the third aspect is represented by the spread of social platforms that have allowed anyone with a web connection to disseminate knowledge in real-time with anyone worldwide.

A large amount of data generated by many people circulates through the web and allowed knowledge to find this new vital space in the digital dimension considering the possibility of storing, processing, and using this resource. This aspect radically changes the options of creating knowledge, which is not limited to the single spiral of knowledge between individuals and human minds but includes a combination of other steps involving digital dimensions. With this empirical evidence, this analysis aims to provide a conceptual model of knowledge creation that considers digital space and highlights the new flows of knowledge between the various dimensions through enabling technologies.

Webinarisation is the process of converting explicit knowledge into digital knowledge. Through webinarisation process, the explicit knowledge created is shared through digital platforms and converted into digital knowledge by the system (Cripps et al., 2020; Kroenke, 2018; Y. Wang et al., 2017). In this phase, the text and multimedia acquisition systems are mainly active, and crowd-based knowledge is carried out to be redirected to the platforms that request it in a second step (D'Andrea et al., 2019).

Informalisation is the process of converting digital knowledge into tacit knowledge. Through informalisation, the digital knowledge that has been accumulated or generated is shared via the web platform and converted into tacit knowledge by the actor who receives it (Buunk et al., 2019; Panahi et al., 2016). Neural network systems, pattern recognition, AVR, and cyber-physical systems are mainly active in this phase (Grum & Gronau, 2017). By simulating certain situations, the system induces the actor to synthesise behaviours and ways related to that situation.

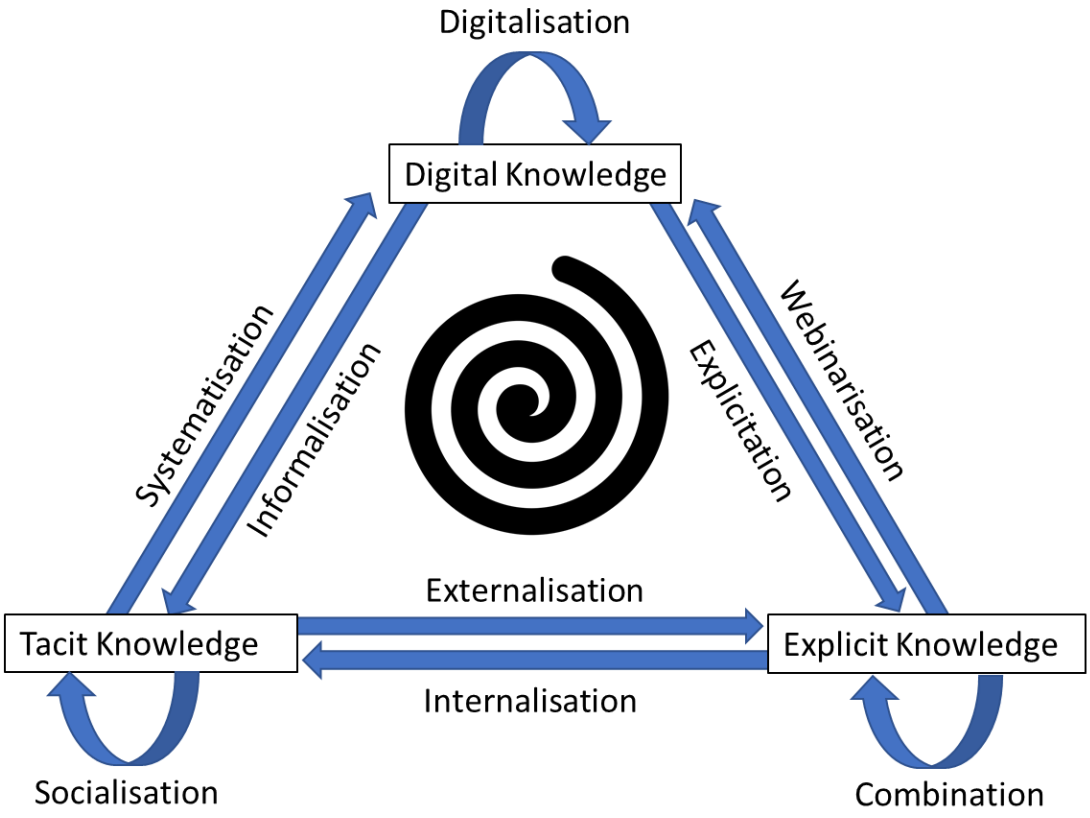


Figure 15 WISED framework

Systematisation is the process of converting tacit knowledge into digital knowledge. The tacit knowledge that imbues the various users' web actions can be summarised and digitised (Atrash et al., 2015; Li et al., 2018). In this phase, data mining, deep learning and NLP systems are mainly active, in this way, AI can synthesise behavioural and cognitive ontologies that can then be used in other cognitive processes by other artificial or human entities (Atrash et al., 2015; Li et al., 2018).

Explicitation is the process of converting digital knowledge into explicit knowledge. Through explicitation process, digital knowledge stored on the web is reworked in texts or multimedia files and proposed to users. AI systems are mainly active in this phase, and they are capable of synthesising data and multimedia files capable of transferring the required concepts to human intelligence (Delen et al., 2013; Lu et al., 2015; Metaxiotis et al., 2002).

Digitalisation is the process of combining digital knowledge into digital knowledge. Through digitalisation, digital knowledge stored on the web is analysed, deconstructed, and reworked by extracting information that was previously not provided or was not accessible; this information is then redirected to other AI if requested (Bibri, 2018; Z. Li, Kang, et al., 2018; Minh Dang et al., 2019; Vanitha et al., 2020). IoT, BDA, and AI are enabling technologies in this phase.

3.5 Conclusions, implications, and future research directions

By implementing this bibliometric study, it is provided a clear result on the structure of the state-of-art of KM literature from the digitalisation perspective. Notably, through the identification of published studies pathways in the field, the analysis has recognised that

SECI model processes has gone through a phase of innovation that has expanded its boundaries and possibilities, involving the creation and circulation of knowledge at multiple levels and in multiple forms.

A total of 7,500 documents (6,929 articles and 571 reviews) on KM were collected and analysed using mixed systematic, bibliometric, and network analyses. The majority of the articles, like all the most cited, have been published in the last twenty years and this enhance the result of our tertiary review that found reviews on KM from the last 20 years. This is not surprising as the field started to grow and develop massively in combination with technological and digital development as well as the globalisation of markets. From the rank of the country most involved in the KM field UK, and USA are the most productive countries and with the highest review citation index on the topic of digitalised KM models, specifically SECI model. This study contributes to the body-of-knowledge on KM while broadening prior reviews in several ways (Asrar-ul-Haq & Anwar, 2016; Durst & Edvardsson, 2012; Kuah & Wong, 2011; Massaro et al., 2016).

First, the present study applies bibliometric and network approaches to uncover the most influential articles, scholars, countries regarding the number of articles published and citations in the field of digitalised KM, going beyond the systematic review of the domain.

Second, scholars working on the logical intersection between digitalisation and KM domains may easily recognise the countries working on KM and thus, perform joint research projects, share their ideas and results.

Third, it proposes five clusters based on keyword co-occurrences, namely webinarisation, informalisation, systematisation, explicitation, and digitalisation. From these clusters it

was possible to identify 5 new way of knowledge creation and circulation opening the SECI model to a new wider digital model.

Fourth, the study supports researchers to underline the most influential articles relevant for the description of the digital KM creation model and further research on the topic.

Fifth, the findings can assist the industries and governments in identifying the leading research and development centres working in KM for research projects, specifically, focusing on the relevant KM phases for their business, focusing on the main technological solutions that can help them to enhance their KM processes. The study further provides managers with diverse outlooks that enable them to enjoy the benefits of digital KM in their work. The bibliometric information about the digital KM literature has immense value for managers as it allows them to spot the KM expertise globally. Accordingly, the research projects on digital KM can be developed considering this information.

Although this article significantly contributes to the state of the art in the KM field, this study has selected only research articles and review articles; therefore, the inclusion of other types of documents may lead to different conclusions.

Thirdly, we performed the co-citation analysis using R and VOSviewer software network analysis. However, other methods and software may be used.

Lastly, the bibliometric analysis in the present study focuses on the general themes of digital knowledge creation processes and is not restricted to KM up to a particular topic.

Some gaps in the literature have emerged from the study of the five new areas of knowledge creation.

The first is the lack of theoretical and practical studies on how tacit knowledge interfaces with the digital sphere, that is in line with the tertiary review results. Although tacit knowledge is difficult to manage, research efforts are required to be able to have solid theoretical bases and application cases to be able to debate on the topic (Brown & Sandholm, 2019; Johannessen et al., 2001).

Moreover, digital creativity and digital intelligence, making differences between information and knowledge, need to be better studied to highlight their main features; furthermore it should be relevant to separate tacit digital knowledge from explicit digital knowledge (Aleksander, 2017; Rainey, 2017). Finally, an additional gap is represented by the lack of empirical studies on corporate performance of the impacts of digital knowledge on business models (Torres et al., 2018).

4 Knowledge management in agile companies: a multiple case study

4.1 Objectives

This paper proposes multiple exploratory cases based on a study for understanding the relationship between KM and the digitalisation process within the context of agile innovation. Numerous articles have demonstrated the connection between KM and an agile environment as well as between digital tools and KM. But the enabling technologies of Industry 4.0 differ from the technologies of the third industrial revolution. Enabling technologies are not only simple tools supporting human processes, but they also have the capacity to add their own value to the process until they change how this process can be done. Besides, the possibility for a digital entity to have autonomous thinking, opens new opportunities in the KM models used, framing Nonaka's hypothesis of a third ontological dimension in the KM framework: the digital knowledge dimension.

Since KM is demonstrated to influence the agile innovation processes, it may be possible that digitisation 4.0 and the new digital knowledge can also affect the agile innovation processes.

Therefore, this analysis aims to give a qualitative evaluation of KM and digitisation 4.0 to academics and industry professionals.

4.2 Theoretical background

Qumer & Henderson-Sellers (2006) define agile as accommodating and adapting to changing environments.

Learning prior knowledge and current experience to deliver high-quality goods under constrained financial and temporal restrictions is known as being agile (Jyothi & Rao,

2012). Thus, agility includes flexibility, velocity, learning, adaptability, and leanness (Campanelli & Parreiras, 2015; Conboy & Fitzgerald, 2004). Agile paradigms are a collection of agile software development approaches that place high importance on people and human contact, incremental software delivery, customer and supplier collaboration, and agility in the face of change (Cram & Newell, 2016; Paluch et al., 2017; Rigby et al., 2016; Senapathi & Srinivasan, 2012). According to a survey by Campanelli and Parreiras (2015), the most popular Agile Paradigm methodologies include Extreme Programming, Scrum, Kanban, Lean, Feature-Driven Development, Dynamic Systems Development Method, Adaptive Software Development, Crystal, and Rational Unified Process.

However, all of them are linked to core values and tenets like: customer and supplier interactions, operational agility and adapting to change (Campanelli & Parreiras, 2015).

Despite the high level of abstraction that these overarching ideals and principles frequently have, they were proposed by expert practitioners (Beck, 2001), who later worked to incorporate them into the agile innovation methodologies currently in use. Moreover, the advantages of using agile methods are well known (Cram & Newell, 2016; De Cesare et al., 2010).

Agile innovation approaches entail numerous brief plan-execution cycles controlled by customer input and quick modification (Beck, 2001; Y. Wang et al., 2017): key components of agile techniques include minimal upfront preparation and continuous customer input (Wang et al., 2012). In this way, identifying continuously the way to create value for the customer is the first step in an agile innovation process.

In agile innovation projects, customers collaborate with the agile innovation team in all phases of the project, gradually defining, at the beginning of each iteration, the requirements to be achieved; contrary to what happens in traditional innovation systems, they are not clearly defined from the early stages of the project and may change (Chan & Thong, 2009; de Castro et al., 2021). This also involves a continuous reengineering of processes to align production to customer needs (Holden et al., 2021; Singh et al., 2014).

Furthermore, in agile innovation projects, unlike traditional innovation systems, the output released to the customer is not unique, but at the end of each interaction, a working prototype is delivered, which must be tested by the customer to obtain feedback (Dingsøyr & Hanssen, 2003; Pooley & Chan, 2021).

Agile innovation projects also promote greater autonomy and accountability for the entire network. However, the increased independence and decentralisation of decisions can lead to conflicts between agile team members.

Therefore, to achieve the advantages of agile innovation practices, it is necessary, in addition to involving the customer at every stage of the process, to establish a relationship of trust and collaboration between team members, suppliers included, to have a single standard objective (Dingsøyr & Hanssen, 2003; Santarsiero et al., 2020; Timinger et al., 2022).

Agile methods and practices are widely used, but scholars also point out some of their potential drawbacks, including deployment challenges, perhaps ambiguous benefits, and a lack of project ownership and accountability if proper knowledge and information management are not in place(Cram & Newell, 2016; Drury et al., 2012; Janes & Succi, 2012; Laanti et al., 2011).

In agile innovation processes, different practices support KM: the rotation of team members to increase the relationships between them and the dissemination of information in other groups (Kevin Sungkur & Ramasawmy, 2014), the use of company databases to store and retrieve information on past projects help carry out current ones (Holz & Maurer, 2003), a discussion forum to identify solutions (C. J. Clark & Mason, 2008) and mentoring by experienced employees who transfer their skills to new hires (Feo et al., 2022).

All the processes used in agile innovation can be traced back to the four phases of the SECI model (Singh et al., 2014), not only for the internal management of individual organisations but also for the entire supply chain management (Bonamigo et al., 2021).

The SECI model is one of KM's most frequently cited theories (Gourlay); it describes the spiralling knowledge processes of interaction between explicit and tacit knowledge. Following are some agile methodology factors that contribute to several knowledge conversions.

Sharing tacit knowledge through frequent personal meetings and a cross-functional team collaborating to share knowledge between distinct organisational divisions supports socialisation. In addition, involvement of customers (product owners) results in further tacit knowledge sharing.

Frequent meetings that result in explicit artefacts facilitate externalisation: vision, goals, release plan, iteration story tasks, acceptance tests, and daily progress record. Besides, every meeting also generates reports and clarifies the rules for evaluating task estimates.

The combination is achieved through activities such as creating a plan in collaboration with the iteration backlog and progress bar, derivation of a new plan and using estimates

in the subsequent iteration. The designed requirements can be combined with the current needs of the customer and modified accordingly. Using the meeting reports, plans, estimates, and daily progress logs, best practices and guidelines for future projects are developed.

Internalisation involves the creation of guidelines and best practices that can be internalised and implemented in future projects. Managing knowledge recommends that agile be used in the enabling contexts of the team's interaction on a successful software project to support knowledge creation, diffusion, and application.

In comparison, SECI appears to be the theoretical framework of the Articulate–Appropriate–Learn–Act–Accumulate–Anticipate (5-A) models for knowledge management in agile software. However, the 5-A model of KM best explains the advantages of agile programming. This gives agile processes a new perspective and allows others to express agile practices more generically.

Furthermore, technology also plays an essential role in the dissemination of knowledge in an agile team; in fact, the use of tools such as e-mails (de Castro et al., 2021), message boards (Singh et al., 2014), websites (C. J. Clark & Mason, 2008), search engines (Benckendorff, 2009), directory of experts (Hidalgo, 2019), real-time communication tools (Heredia et al., 2014), online forums (Feo et al., 2022), newsgroups and mailing list (Inayat & Salim, 2015), allows the company to communicate continuously and directly with customers and favours the knowledge diffusion in the entire supply chain where individuals are not necessarily in the same place (Heredia et al., 2014; Inayat & Salim, 2015; Pershina et al., 2019).

At this point, the importance of a KM culture for the success of an agile innovation project is relevant: knowledge must be effectively created, shared, transferred and applied among the components of the network. To support the tacit component can be used team member rotation practices (Kevin Sungkur & Ramasawmy, 2014) or instant messaging systems (de Castro et al., 2021; Inayat & Salim, 2015), videoconferencing (Heredia et al., 2014) and online forums (Feo et al., 2022; Hidalgo, 2019). For the explicit component, on the other hand, the main tool used is shared databases (Kevin Sungkur & Ramasawmy, 2014; Khalil & Khalil, 2020).

But the agile innovation techniques, due to their propensity to update usable tools, have also received great support from I4.0 technologies.

Big Data, being databases that allow collecting and managing large amounts of unstructured data, can be analysed and transformed into knowledge through the data mining process: it will enable one to obtain a forecast of market demand and plan production (Raji et al., 2021). In addition, big data allows the creation of digital archives to facilitate access and use of data and information within companies (Barlow & Bocko, 2020; Rafi et al., 2020).

Cloud Computing is another I4.0 technology that lends itself well to supporting big data by storing, processing, sharing and displaying data on the network and allowing the various actors involved to share and access information in real-time and speed up the operations (Ching et al., 2022; Fakhar Manesh et al., 2021). In addition, cloud technology allows companies to create a virtual space to store documents and information, classifying them according to the business unit of origin or destination (Raji et al., 2021).

Instead, the Internet of Things (IoT) allows the tracking of materials and processes in order to ensure that products are sent to the right place, in the right quantity and at the right time, reducing process times and costs (Fakhar Manesh et al., 2021; Hsu et al., 2006; Raji et al., 2021; Teoh & Cai, 2015). Besides, implementing the IoT has improved the sharing of information between team staff and reduced waiting times, improving their performances and customer service level (Teoh & Cai, 2015).

Augmented reality and virtual reality technologies, on the other hand, are often implemented in agile innovation projects to give the customer an idea of the product that will be created and to obtain more precise feedback (Bettiol et al., 2022; Pieska, 2019; Tønnessen et al., 2021). Furthermore, the technologies of augmented reality and virtual reality find application in different fields: in the health sector, they allow for improved rehabilitation activities (Pieska, 2019); in the building field, they allow to evaluate of the buildability of structures (Terentyeva et al., 2020), while in the production sector, they facilitate maintenance activities (Tønnessen et al., 2021).

AI not only allowed companies to access new levels of information through data mining and forecast algorithms used on big data, but it has also changed consumer behaviour by shifting their preference to interacting with artificial intelligence systems to interacting with people (Davis et al., 2015; Olan et al., 2021). These AI systems learn based on online interactions, understand questions, predict what customers want to buy and allow buying with the illusion of human interaction, without denying that AI systems can transfer information about the habits of the customers up to the organisation owning the AI systems (Ching et al., 2022; Davis et al., 2015; Olan et al., 2021). Organisations, therefore, exploit these digital tools to predict consumer behaviour (Ching et al., 2022; Davis et al., 2015; Olan et al., 2021).

The set of I4.0 technologies used simultaneously within organisations allows the creation of Intelligent Factories: they enable the company to acquire, analyse and share data in real-time, increase production flexibility and improve communications between the various players in the supply chain and support the processes of acquisition, processing, transformation and use of knowledge (Ardito et al., 2021; Cornélio et al., 2010; Ribiere & Tuggle, 2010).

This is part of the theoretical debate on how new technologies support and modify KM processes (Cerchione et al., 2023). The SECI model, which for twenty years has fully described the dynamics of KM, now finds itself with processes in which the digital components are no longer straightforward support tools but actors in the process. For this reason, this research aims to identify the relationship between KM and digitisation within the context of agile innovation.

4.3 Material and methods

This research was developed as an exploratory multiple-case study (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; R. Yin, 1984). A case study is a qualitative investigation that examines a contemporary phenomenon from its real-world perspective; when the boundaries between phenomenon and context are not clear; and in which multiple sources of evidence are employed (Yin, 1984). An inductive qualitative approach must be used because of the research's emergent and experimental nature and the need to answer a broad research question (Creswell, 2003). Specifically, a multiple case study with a grounded theory approach has been adopted and primary data has been collected by conducting semi-structured interviews (Cabanelas et al., 2013; Creswell, 2003).

Data analysis in a grounded theory approach can be conceptualised as a series of three coding steps (Johnston, 2014). The first step in data coding is open coding. In open

coding, all meaningful quotations are assigned to a higher-level major category of information. Subsequently, these categories are further organised through axial coding. In axial coding, the open codes are investigated to uncover the central phenomenon as well as the categories around the major phenomenon, such as categories that influence the core phenomenon, strategies for addressing the phenomenon, contextual and intervening conditions and consequences of undertaking the strategy (Johnson, 2014). The final step consists of selective coding. During the selective coding, all categories are unified around a central category, and categories that need further explication are filled-in with descriptive detail (Johnson, 2014). Selective coding integrates and connects the identified axial codes and creates an articulated theory (Johnson, 2014).

At this point, it is possible to use the understanding of the phenomenon along with the data to develop a conceptual model explaining the theory and providing appropriate connections between the axial codes. The semi-structured interviews get the advantage of having a set of pre-established questions without limiting respondents' answers and allowing them to add further details (Qu & Dumay, 2011).

In multiple case studies adopting the grounded theory, the sample size is not predetermined but adaptively estimated using observed data Yin, 2009). Within our multiple case study, we examined the KM digital innovation process within the context of agile innovation undertaken by four distinct digitalising organisations in authentic environments that vary in terms of investment in digitalisation - moderate/low or high - and the relative role played by the organisation - which can be subject to or rather determine this digitalisation. Following Van Maanen (1979) and Clark et al. (2010), we opted for an inductive research approach, which gives the actual event participants a voice in interpreting first-order events. Then, we formulated a second-order interpretation of

the respondents' comments, including but not limited to references to KM theory, which may have contributed to theory development.

Although exploratory theory-building research should begin with little or no theory under consideration and no hypotheses to test - because predetermined theoretical perspectives or propositions can lead to incorrect and limit the findings - Eisenhardt (1989) argues that it is nearly impossible to begin with a theoretically blank slate. In an effort to follow an exploratory approach consistently, a neutral stance is maintained when asking respondents to describe or recall the digitalisation process they underwent and what altered their approach to digital KM processes from the agile innovation perspective. In order to perform the multiple case study, KM and Agile theory served only as a jumping-off point for formulating a sufficiently broad research question and thus initiating the data collection process (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). Before or during the interviews, the informants were not exposed to any predetermined relationships with other theories or approaches.

Case sampling was conducted theoretically (Eisenhardt, 1989; Meredith, 1998), and following our interpretive stance. Cases were selected based on how heterogeneous they were in terms of two relevant variables that may have influenced the digital KM processes: (i) investment in digitalisation - moderate/low or high; and (ii) the organisation's role in terms of being subject to or determining such digitalisation process. Following this decision, four relevant digital business organisation case studies are identified. As Meredith(1998) suggested, the analysis of secondary sources also influenced the level of digital investment and the digital organisation's role within its environment.

We opted for a multiple case study because this method may strengthen the process of generalising results (McGrath, 2010; Meredith, 1998), while also allowing for a comparative analysis of the findings, as the theoretical sample may contain extreme cases, polar types, or niche situations (Meredith, 1998). Despite this, the small number of respondents in the sample allowed us to retain the advantages of a single case study approach in terms of obtaining a comprehensive qualitative description and analysis of the topic, as well as the required depth and insight, which is difficult to replicate on a larger sample (Handfield & Melnyk, 1998). In each example, our unit of analysis was the digital effects on KM and Agile processes, with their steps and constituent elements serving as potential sub-units of analysis.

4.3.1 Data gathering and analysis

During multiple case studies, information was gathered from various sources (Yin, 1984).

The primary source of information was semi-structured, face-to-face interviews. Due to the semi-structured nature of the interviews used in the data collection process, interviewers were able to begin from a list of critical issues derived from the research questions - and thus avoid leaving themselves at the mercy of the interviewee - while allowing any innovative subject to emerge from the ensuing open discussion (Walsham, 1995; R. Yin, 1984).

According to Melander et al. (2019), a purposeful sampling approach was used in this study in the participant selection. This approach entails choosing only participants who can transmit crucial information as interviewees; additionally, this approach is more effective the smaller the number of interviews that can be conducted in the study. As a result, the following inclusion criteria have been established for company selection:

• Participation: The organisation must actively participate in the interview and share its expertise on the themes.

• Sector: The organisation must be associated with a relevant digitalised sector.

• Adequate technology and interest in innovation: The organisation must be considered at the cutting edge of technological and digital innovation, or the very least current.

The organisations and representatives contacted are summarised in Table 5 Overview of responding organisations where all organisations' names have been masked to maintain confidentiality.

Table 5 Overview of responding organisations

Case ID	**Type**	**Average staff number (2019)**	**Revenue (mln. €) (2019)**	**Role of the interviewee(s) in the company**
A	Manufacturing	200	16	Research and Innovation coordinator
B	Service	50	4	CEO
C	Service	15	0.8	CEO
D	Manufacturing	70	3.5	Quality testing coordinator

Initially, two pilot interviews with two founders of digital organisations were designed and conducted, not including them in the theoretical sample but being well-versed in the topic due to their participation in previous studies. The pilot interviews allowed to check

that the research questions and related sub-questions were straightforward to the informants and could contribute to insightful discussions; however, the pilot informants' feedback resulted only in minor changes to the question wording to improve clarity.

After conducting pilot interviews, the researchers conducted four semi-structured interviews with the four organisations. The interviews were conducted from October to December of 2022 and each interview lasted from 70 to 90 minutes.

The interview protocol was consistent with the study's research question: respondents were asked to describe and comment on their organisation's digital KM process. In addition, the respondents were asked to discuss the key phases of this digital KM process and the constituent elements on which they concentrated. As a result, after a first set of general questions, the interviews included inquiries about digital innovation strategy, agile background, and a final set of questions about utilised KM processes and models.

Table 6 provides a comprehensive list of the questions guiding the semi-structured interviews.

As case studies rely heavily on the accuracy of the information presented by respondents for their validity and reliability, and these can be improved by using multiple sources or trying to look at data in multiple ways (Eisenhardt, 1989; Yin, 2003), several secondary and archival data were also introduced to support the interview data, such as balance sheets, budgets and project reports, internet pages, and whitepapers.

This variety of sources resulted in data triangulation, an essential component of trustable and compelling qualitative research (Bonoma, 1985; Siggelkow, 2007). According to Yin (2013), there are no benchmarks defining when triangulation might be recognised as strong or weak or complete or incomplete, a recursive process is followed, gathering and

evaluating a first set of secondary sources before conducting the interviews and arranging a second set of secondary sources that were cited or delivered by the respondents during or after the consultations. The process of data triangulation considered all secondary sources obtained at various stages of the process.

The interviewees' responses were recorded and fully transcribed. If any information remained unclear or if additional information was required, the respondents were subsequently contacted.

Then, following Eisenhardt's (1989) recommendations, a within-case data analysis was conducted to generate the necessary insight into the examined issues; a subsequent cross-case analysis allowed us to compare the various responses provided by the various informants.

Regarding the within-case analysis, interview content analysis was carried out using the open coding procedure from the Grounded Theory method (Glaser & Strauss, 1967; Strauss & Corbin, 1998). The empirical material was coded via textual analysis, and for each case, we constructed an inferential coding tree based on both direct and constructed codes (Glaser & Strauss, 1967), noting the exact terminology used by the respondents to define the investigated process, as well as the terminology induced by the researchers. Each organisation's interview-related codes were characterised and matched iteratively in order to organise them into sets of first-order concepts. These first-order concepts were then organised into a set of second-order themes or categories, enabling us to view the data more abstractly (Clark et al., 2010).

Ultimately, as a third and final step, the second-order themes were categorised into broader dimensions that caught the essential steps and constituent elements of a KM

process. Finally, the inductive coding tree converted fine-grained real codes into aggregated concepts, allowing us to continue with abstraction and theory development (Saldaña, 2009).

Using cross-case analysis, we sought similarities and differences between cases regarding first-order concepts, second-order themes, and, most importantly, overarching dimensions (Yin, 1984). This final procedure allowed to compare and correlate the KM process steps and constituent elements of the four digital organisations, making the most of the multiple case studies to capture any novel findings that may have emerged from the data (Eisenhardt, 1989 - p. 541).

In conclusion, the respondents examined and verified the case results to potentially correct any errors or biases and ultimately improve the accuracy of our interpretations.

4.4 Discussion of findings

This section discusses the findings of the cross-case analysis highlighting the relationship between KM and digitalisation within the context of agile innovation. First, themes emerging from the data analysis were grouped into first-order categories and followed by a more general cluster of second-order. Finally, aggregate dimensions were synthesised to build a new theoretical model. Questions and the whole inductive coding tree is reported in Table 6.

Table 6 Questions and the related inductive tree

		1st order	**2nd order**	**Aggregate dimension**
What is your position in the organisation?	Bonamigo et al., 2021			

How long did you work in this organisation?	Bonamigo et al., 2021			
What is the number of employees and the annual turnover of the company?	Bonamigo et al., 2021			
What was and what is your strategy in the field of digitisation and Industry 4.0? What are the enabling technologies that have been introduced in your company?	Chirumalla, 2021	Digital strategies	Technological vision	Digital transition
What have government tools and/or incentives been used for this implementation?	Chirumalla, 2021	Government incentives		
How has the adoption of these technologies impacted on business processes? What were the challenges faced in implementing these technologies?	Chirumalla, 2021	Digital impact	Digital transition impact	
What is the payback period of the investments made?	Rossini et al., 2021	Payback period		
Within your business model, how is customer value generated? And how are customer requests mediated with the organisation's needs?	Ghezzi & Cavallo, 2020	Customer value creation	Customer value	Agile and I4.0
Regarding your cost structure, is there scope for reengineering products/processes to cut costs and/or resource usage?	Ghezzi & Cavallo, 2020	Cost structure		
What is the process of identifying and solving problems within your business model? Do you use specific methodologies/models/approaches/tools to facilitate and enable this process?	Ghezzi & Cavallo, 2020	Problem resolution	Supply chain agile approach	
Is there a collaboration with your suppliers during the product/service design phase?	Ghezzi & Cavallo, 2020	Design collaboration		
Regarding upgrading your resources/skills, what is your policy? And on the other hand, is it difficult to divest from obsolete resources/skills?	Ghezzi & Cavallo, 2020	Skills updating	Organisational agile approach	

How have the new Industry 4.0 technologies been implemented in the company? Were specific courses necessary to align the operators with the use of these technologies?	Rossini et al., 2021	I4.0 training	Technology innovation	
Do agile practices go well with those of Industry 4.0?	Rossini et al., 2021	Agile 4.0		
Does your organisation have an area dedicated to knowledge management or is it grafted onto other areas (such as research and development or human resources)?	Bonamigo et al., 2021	KM department	Agile KM	Digital KM
What tools or practices does your organisation use to manage knowledge (e.g. email, video calls, centralised databases, manuals, ERP systems)?	Bonamigo et al., 2021	KM tools		
What about knowledge acquisition practices inside and outside the organisation?	Bonamigo et al., 2021	Knowledge aquisition practices	KM processes	
What about knowledge storage practices?	Bonamigo et al., 2021	Knowledge storage practices		
How acquired and stored knowledge is put into action?	Bonamigo et al., 2021	Knowledge application processes		
What about how the knowledge present in the company is disseminated?	Bonamigo et al., 2021	Knowledge diffusion processes		
How do you think the digital transition can support the conversion of a worker's explicit knowledge? What are the technologies that can support this development?	Cerchione et al., 2023	Digitalisation support to explicit knowledge	WISED KM	
What are the mechanisms for converting explicit knowledge into digital? What are the technologies that can support this development?	Cerchione et al., 2023	Explicit knowledge digitalisation		
How do you think the digital transition can support the conversion of workers' tacit knowledge? What are the	Cerchione et al., 2023	Digitalisation support to tacit knowledge		

technologies that can support this development?				
What are the mechanisms for converting tacit knowledge into digital? What are the technologies that can support this development?	Cerchione et al., 2023	Tacit knowledge digitalisation		
Within the digital space, are there margins for independent thought and, therefore for the creation and dissemination of completely digital knowledge? What are the technologies that can support this conversion?	Cerchione et al., 2023	Digital knowledge		

According to Sharma et al. (2022), due to globalisation and digitisation, companies operate in an increasingly complex and competitive market where customer demand changes very rapidly. Furthermore, Cassia et al. (2020) argue that companies must continuously innovate by promoting the implementation of new I4.0 technologies to be competitive and respond quickly to market changes.

In fact, the companies interviewed have been involved in this digital revolution and have implemented the new I4.0 technologies to improve internal efficiency and efficacy and provide better solutions to customers.

In particular, organisations C and B are born in the digital age. Thus, these firms have not undergone the analogic-to-digital transformation that organisations A and D have faced. Furthermore, organisations B and C are businesses that offer services, unlike A and D, and this implies that the leading technologies used are light-enabling technologies, which have a minimal hardware investment.

Currently, all the organisations interviewed have stated that they have achieved a high level of digitalisation concerning the activities or processes that can be digitalised. In particular, organisation A, unlike the other organisations, stated that "*although it would be possible to increase the level of digitisation of the processes, we still prefer to keep a*

non-digitised part due to leave the possibility for employees to be able to insert human creativity that is not yet possible to transfer digitally".

To implement their digitalisation strategy, organisations B, C and D use ISO certifications for information management and security and for research and development. Furthermore, they took advantage of the state's tax plan incentive for research and development. This implies the possibility of having smarter systems, while still maintaining a validation of own quality and digital security recognisable worldwide. On the other hand, Organisation A is larger in size than the others; therefore, to implement own digitisation strategy, beyond taking advantage of European and state incentives, such as super depreciation, they have also used, if not mainly, resources own.

Quoting interviewee A, all the organisations stated that: "*the payback period of the investments made for the implementation of the new I4.0 technologies is around a couple of years, except for investments in hard technologies*", and interviewee D added that "*payback period for CPS and robots can vary from 5 to 10 years, depending on the complexity of the implemented system*".

The I4.0 technologies most used by organisations to support business processes are: IoT, big data, horizontal and vertical integration systems, AI, blockchain, augmented/virtual reality, cloud comupiting, CPS, robotic systems, and additive manufacturing.

The combined use of these technologies allows companies to acquire, process and share data in real-time (Davis et al., 2015), facilitate communications with suppliers (Ching et al., 2022; Hannola et al., 2018; Lima, 2020; Rialti et al., 2019) and automate the management of production, maintenance and procurement of materials, through the use of robotic systems (Ching et al., 2022).

The I4.0 technologies that the organisations interviewed have implemented to support business processes are shown in Table 7 where in each box it is counted how many organisations have adopted that technology for that process.

Organisations B and C are much more oriented towards the adoption of soft enabling technologies than they consider these technologies as commodities. Interviewee B states that these are "*technologies that are easy to use and have enormous strategic value as they represent the point of contact between the real world and the digital world, but which do not bring any added value*" (Fakhar Manesh et al. 2021; Hsu, Ke, & Yang 2006).

On the other hand, organisation A adopts, for development and testing, robotic technology and augmented/virtual reality.

Finally, organisation D, being in an allied business with large global automotive manufacturing company, integrated big data analytics, simulation technologies, and CPS. In particular, organisation D stated that: "*the implementation of CPS, has improved the production and quality control processes and the big date produced as information output from CPS are very valuable to be analysed and better understand the process behaviour*". In fact, CPSs acquire and archive data on the production process in real-time, allowing the company to prevent breakdowns, plan machinery maintenance activities, and improve production quality (Fakhar Manesh et al., 2021).

In order to obtain good performances, organisations must continuously innovate, and in this they are supported by agile innovation models. Agile innovation practices are based on collaboration with customers and the ability to respond to volatile market demand (Capaldo & Volpe, 2021).

All the organisations interviewed adopt agile innovation practices; they generate value for their customers by creating innovative solutions and products that meet their

requirements. In particular, organisations B and C define themselves as "*custom-centric*", that is organisations where great importance is given to the customer and his needs. In these contexts, customers collaborate continuously with the organisation, especially in the conception and design phases, in which the product/service requirements to be created are defined (Dingsøyr & Hanssen, 2003; Holden et al., 2021; Inayat & Salim, 2015).

However, in organisation A, agile innovation practices are only partially adopted, that is, only for the implementation of projects with intangible outputs, while they are not used for the implementation of tangible outputs, "*whose requirements requested by the customer, generally are defined before the supply phase and seldom change in the subsequent phases*".

Furthermore, in organisations A, B and C, the interaction with customers is direct; instead, in organisation D, customer needs are identified through market research, prototype testing and benchmark analyses on competitor products to evaluate the technological solutions used and their impact on customer satisfaction.

In organisations A and D, unlike in organisations B and C, there is an intense collaboration with the suppliers during the design and manufacturing phases of the product.

However, currently, the collaboration between organisation A and its suppliers "*is based on unstructured processes but, within the next year, the integration of the company ERP with the suppliers is expected to structure the collaboration processes and obtain mutual benefits*".

Organisations B and C stated that no difficulties were encountered in implementing I4.0 technologies, but it was necessary to provide training courses and create collaborations with research centres, to align the operators with the use of the new technologies implemented.

Conversely, organisations A and D, have encountered problems implementing the new I4.0 technologies. For example, in organisation D, to be ready to use the latest machinery, it was necessary to plan the partial shutdown of the production lines and provide refresher courses aimed at all staff on the new work procedures and the potential of the machinery installed.

Furthermore, the organisation has encountered problems in implementing cybersecurity technologies related to obtaining authorisations for acquiring information from suppliers. Organisation A, on the other hand, uses these technologies to support agile innovation processes, when a new project is born, there are organisational problems related to identifying the right people to be involved in its execution and the creation of a fair trade-off between the working hours to be dedicated to the project and those to be used for the business unit to which it belongs.

The organisations interviewed adopt different skills updating policies. For example, the approach adopted by organisations C and D provides weekly hours dedicated to employee self-training. In organisations A and B, on the other hand, the heads of the various business units identify the training needs through interviews with the employees. To meet the training needs identified by the interviews, the organisation provides training courses, on-site and online, held by external and qualified people who bring cognitive value to the organisation. Furthermore, employee training in organisation B is considered a contract paid by the customer, as it allows the company to increase its skills and meet customer needs.

From a KM perspective, I4.0 technologies facilitate the sharing of knowledge in an agile environment, they reduce the distance between company and customer, allowing organisations to interpret their needs better (de Castro et al., 2021; Singh et al., 2014). In

particular, new enabling technologies are significant for knowledge sharing in virtual teams, considering that they are made up of individuals who do not work in the exact location. The interviewee of organisation D asserted that: "*agile practices go very well with those of I4.0, especially due to the size and decentralisation of our organisation*" (Hidalgo, 2019; Holz & Maurer, 2003).

The most used digital tools for sharing information among virtual agile team members are real-time communication tools, cloud technologies, horizontal and vertical integration systems, newsgroups and mailing lists.

The interviewee of organisation D asserted, "*For the management of information flows and documentation, we use social communication platforms (both messaging and video conference) and document depositories. Employees can independently schedule meetings and share text, audio and video files to show the results of their activities*".

As regards the support given to the various forms of knowledge present in the company, the interviewees provided exciting ideas, even if they were not familiar with the theme of KM from a theoretical point of view. In organisations B, C and D, cloud technologies and digital tools allow information to be stored on the network, facilitating its sharing and access, as also supported by (Khalil & Khalil, 2020).

The interviewee of company B asserted that: "*the digitisation of the documentation used by mail or for meetings and the consequent creation of cloud systems certainly support the creation of easily consultable digital knowledge*". Furthermore, organisation D adds that "*data and information present in clouds or databases can also be easily used by digital entities to control production processes, as often happens with CPS systems that monitor production cycles, limiting the exposure of operators to possible risks*.

Cloud systems, combined with horizontal/vertical integration systems, make it possible to make data and information instantly available at all epistemological levels of the organisation.

If the processes concerning the explicit/digital sphere are evident and structured, the same cannot be said for the tacit/digital ones that can still not find massive practical applications. Tacit knowledge is difficult to digitise because, through digital communication systems, physical contact and personal interactions, fundamental for its transfer, are missing (Paez-Logreira et al., 2016). In organisations A and D, the implementation of solutions for the conversion processes of tacit/digital knowledge is being evaluated. The use of AI and virtual reality technologies could support these processes. Organisation D reported: "*AI technology, especially machine learning, can greatly assist in converting tacit knowledge to digital. If behavioural patterns are recorded, it is possible to recreate scenarios that AI can analyse and return data and information for training and decision-making that can be of enormous added value*". However, as can be seen in Table 7, none of the companies interviewed currently adopt I4.0 technologies to support this knowledge conversion process. In fact, the companies believe that "*this solution is not yet feasible in the short term*" quoting the organisation B.

But the surprising result is that the implemented digital tools can also be the end users of the KM processes.

The organisations interviewed argue that it is possible to create and disseminate knowledge within the digital space without the intervention of the human mind. One of

the main solutions in this area is certainly the one reported by organisation B in which "*ontologies of frequently asked questions are loaded into the database of a chatbot which interacts with the customer in the first instance when he tries to contact us for a possible problem with the service. This chatbot is supported by AI technologies that try to respond based on the ontologies loaded and memorise the various possible customer requests to connect them to already loaded ontologies if the question is not already present in the database*".

Organisation D argues that: "*implementing these types of KM solutions would be able to streamline many production processes, giving operators more time to dedicate to quality control. Furthermore, staff safety would also be greatly improved, given that through IoT solutions, the process and the environment can be monitored by AI solutions that can modify the robot and CPS parameters up to even blocking everything if there are possible risks. But training through augmented or virtual reality can also be relevant; in fact, it would be possible to design software that recreates operating situations and evaluate how the operator behaves and memorise these behavioural patterns in the cloud, due to use them later in the operational phase like happened in our American division. This, however, involves a strong digitisation and integration of the systems*".

Adopting agile innovation models is greatly supported by adopting digital technologies aimed at disintermediating the actors throughout the information and knowledge management process to optimise times and processes tailored to everyone. It is no coincidence that cloud computing systems, real-time communication systems and horizontal/vertical integration solutions are the most used.

Table 7 I4.0 adoption in the new KM model

	Agile innovation			KM processes					WISED model				
	Operational Agility	Customer Interaction	Supplier interaction	Creation	Aquisition	Storage	Diffusion	Application	Digitalisation	Webinarisation	Explicitation	Informalisation	Systematisation
Real-time communication System	4	4	4	4	3	3	3	1		4	4	1	
Cloud Computing	3		4	4	3	4	3	1	4	4	1	1	
Horizontal / Vertical Integration System	4	2	2	4	3	4	4		2	2	3	1	
Big Data	1	4		4	4	2			4	2	3		
IoT	1	4		4	4				4	2	1		
AI	2	4		4		2		3	1	2	2		
Augmented / Virtual Reality	2	2		2			2	1				2	
Blockchain	2		1	2	1	1	1		2				
Robotic System	2			2	2	2		1					
CPS	1			1	1	1			1		1		

However, of the various technologies with a more consistent hardware component, only virtual/augmented reality appears to have achieved particular use in recent years due to its significant potential for interacting with customers.

Regarding KM processes, various organisations use intensively enabling technologies to support knowledge creation and acquisition and the related storage process. This is undoubtedly due to the great potential that IoT systems, big data, clouds, horizontal/vertical integration and communication systems and AI have, especially if integrated.

Blockchain systems for data security also seem to have a particular indirect added value in the creation and storage phases, even if, at the moment, they are not yet massively implemented in the various processes analysed, as sustainable blockchain solutions are emerging only in the last years.

On the other hand, the knowledge application appears to have little support except for AI technologies, thanks to their predictive abilities. This scarce support could be connected to the need to work on knowledge with large percentages of tacit components on which current enabling technologies have not yet been able to fully fit.

The diffusive component of sharing and transfer instead returns a partially ambiguous result, even if its intensity of use is not comparable to that of knowledge creation, this limited support could be explained by the fact that the unit of analysis was the single organisation and not the entire supply chain where diffusion processes are much more present and evident. If, on the one hand, the absence of technologies such as robots, CPS, IoT is not surprising, on the other hand the absence of AI and big data as technologies for sharing and transfer of information is certainly relevant.

The explicit and digital component of knowledge appears to be the one most supported by enabling technologies and on which organisations have more pooling possibilities. Even if digital, it is always possible to recreate an explicit type of output that can be shared and used by human actors in any decision-making process, as long as one does not want to leave this decision-making process to digital intelligence.

The tacit component, on the other hand, is challenging to integrate with enabling technologies. If organisation D affirms that its employees indirectly manage in some way to resume unconscious patterns present behind a set of data or manuals, none of the

organisations believes that the enabling technologies adopted can transform the tacit behaviours of the employee into a digital form.

One of the main limitations of this process is related to privacy aspects. In fact, it is not yet possible to film employees and digitise their behaviour to have them analysed by predictive AI technologies. Although, being able to find a solution to this limit, it would be able to keep more knowledge developed in the organisation internally when employees leave at the end of the day. The testimony provided by the four organisations, however, testified to the creation of a new pattern of knowledge management both at an ontological and epistemological level due to the creation of an autonomous dimension of knowledge.

4.5 Conclusions

This research aims to evaluate the adoption and related effects of I4.0 enabling technologies and KM processes by analysing organisations operating in an agile innovation perspective. The scarcity of theoretical and empirical research in this field, and the fragmentary state of existing ones, justifies the need for this research and the use of a qualitative methodology such as semi-structured interviews.

From a theoretical point of view, our results show that I4.0 technological advances can be included in the KM and agile innovation scientific debate. A link has been established between the main technologies that define the I4.0 paradigm and the key elements that define the KM process from the perspective of agile innovation theory.

Furthermore, the field analysis has highlighted that the main enabling factors of a KM system are people's processes. Therefore, developing work teams composed of the most qualified people with different skills is essential. In addition, the team must organise training activities for employees to prepare the entire organisation for the correct use of technologies in order to take full advantage of their benefits.

Consequently, it is strongly recommended to digitise as many procedures as possible to create a digital twin of an organisation that is as true to reality as possible. This would allow organisations to have real-time access to massive volumes of data and information, which they can use to assess crucial processes across various areas critically. The results that emerged from the empirical analysis have shown that the applications of I4.0 technology, in particular the technologies that respondents defined as light (i.e. cloud computing, big data, IoT, AI, real-time communication systems, horizontal/vertical integration systems), determine evident economic and organisational competitive advantages linked with the better management of knowledge. New knowledge can be created or acquired due to the better digital calculation capability, stored and made ready for everyone in the organisation and shared and transferred with other members inside and outside the supply chain. But the potential impact of I4.0 technologies is also evident in the customer value: customer expectations are captured through big data stored in cloud databases, processed with AI technologies to create a new level of customer value and deliver this value with the product/service provided to the customer after several experiments and tests the results of which are always stored in the form of big data, ready to be reused for future processing on quality and safety or the creation of new products/services. So, this digital competitive advantage can be found significantly in the organisation's agile innovation, given that the processes appear to be disintermediated but always connected after their digitisation and, therefore, with better manageability.

However, one point on which all the interviewees agree is that the possibility of digitising human behaviour outside of specific research conditions is not yet possible, for both privacy reasons and the employee's trend to hide particular behavioural dynamics when monitored.

Specific applications of these technologies, possibly in an integrated manner, would make it possible to generate further added value in the design, production, business-to-business and customer service phases making the organisation an intelligent firm. It is precisely customer management that appears to be significantly supported by the implementation of this set of technologies which brings the customer within the boundaries of the business in perfect line with the agile perspective. Even the suppliers in the same agile perspective are integrated from a digital point of view, even if the processes involved are currently limited to social messaging and coordination of activities. Many of the barriers that hinder the exploitation of digitisation are primarily due to the specific structure of the activities that may be more difficult to digitise and, secondly, to the costs that some solutions have. A clear example is that of robots and CPSs, which, due to their high cost of implementation, require companies that supply products with high-profit margins to repay the investment.

4.5.1 Theoretical implications

The results show that the results in managing a KM system are inextricably linked to research in the digital field, especially if the organisation's processes are developed from an agile perspective. Consequently, this exploratory analysis serves as a foreshadowing for practitioners, researchers and policymakers, highlighting the most adopted and promising technologies for a business, be it manufacturing or service. Furthermore, even if specific to organisations structured on agile practices, the theoretical model developed can be replicated in other contexts, and further research can be conducted in this direction. If the adoption of integrated digital systems seems to affect agile innovation processes, this is also due to the mediation that the KM has in this process. In fact, if the positive effect of a traditional KM system had already been verified previously, nothing had yet

occurred for models in which I4.0 digital tools had an active and relevant part in the process. Globally, all KM processes, except the knowledge application, are positively impacted by the adoption of enabling technologies, especially when integrated in order to create scale synergies between the various technologies. Going into the specifics of the nature of knowledge, those processes in which knowledge is highly codified (either by a human or digital mind) indeed find the best benefits. On the other hand, when we talk about tacit knowledge, it is much more challenging to be able to detect when and how I4.0 technologies can support the processes of converting this form of knowledge into digital and vice versa. For this reason, it would be interesting to study these dynamics more specifically in a future development.

4.5.2 Implications for managers and policymakers

The results of this research report have several practical implications for knowledge managers and business managers in general. Adopting light I4.0 technologies (i.e., cloud computing, IoT, big data and AI) are essential for correctly digitising one's processes. In today's increasingly connected world, these aspects have the potential to generate significant economic value by improving coordination and collaboration in KM processes. Such integrated technologies could be a fundamental tool for a more open and shared attitude, if not even one of trust throughout the value chain if there were complete integration also externally. These technologies will positively impact all the processes on which they will be integrated. Having up-to-date information means responding efficiently to sudden internal requests connected to the highly variable demand of customers and the entire market. It might be interesting to conduct further research from a supply chain perspective to evaluate the impacts of adopting such technologies. Furthermore, blockchain technology has emerged as a promising technology for

enhancing trust in knowledge creation, storage and diffusion. However, hard technologies (i.e., robots, CPS, augmented/virtual reality) are difficult to implement for supporting knowledge management processes due to their implementation costs. Additionally, robots and CPS are solutions that come close to being implemented in service organisations due to the outputs they provide.

Both sets of technologies fundamentally impact the transition processes of knowledge between explicit and digital forms. These technologies can easily switch from one form to another and manage the processes in which these forms of knowledge are involved, especially those of creation, acquisition and storage.

4.5.3 Limitations and future research

While this research has contributed to the literature on the digitalisation of the shipbuilding industry, it has some limitations. The first limitation is that the adoption of one or more technologies was not evaluated, and the technology adoption level was captured quantitatively among the various companies interviewed. Second, a higher number of cases need to be implemented for a stronger result. Third, future research should replicate our approach in different contexts or countries. Fourth, the identified features should be operationalised further as measures allowing quantitative empirical testing of the proposed propositions.

5 *Knowledge diffusion in the supply chain: an empirical investigation*

5.1 Objectives

This research proposes a hybrid model for understanding the process of knowledge diffusion within a triadic relationship between the customer, first-tier supplier, and second-tier supplier. This need, as highlighted in the results of the tertiary analysis carried out in chapter 2, is related to the scarcity of works that use a quantitative approach to investigate the dynamics of knowledge sharing and knowledge transfer within a supply chain that go beyond the simple dyadic customer perspective. Knowledge management processes, particularly knowledge sharing and transfer, are critical to process innovation, resource optimisation, and worker safety (Bhosale & Kant, 2016). Transfer and sharing can be facilitated through the use of appropriate support technologies, but there is a scarcity of simulations and empirical investigations to assess their dynamics qualitatively, even without focusing on the technological variable (del Rosario Perez-Salazar et al., 2019; Zerbino et al., 2018).

Today's supply chain is a multi-objective system traversed by multiple resource flows, but how the knowledge flow behaves throughout the supply chain is not yet totally clarified.

For this reason, this research proposes a model analysing the first-tier suppliers' knowledge diffusion flows based on the Analytic Hierarchy Process and the Fuzzy Set Theory. By examining a sample of 18 supply chains, it is attempted to determine how the triadic relationship can explain knowledge diffusion through the supply chain.

Many previous contributions have focused solely on customers and first-tier suppliers, with little or no consideration for relationships with second-tier suppliers. This research tries to connect the three main supply chain actors in a triadic model, making an evaluation considering their opinion directly.

5.2 Conceptual framework and model development

The concept of knowledge has been analysed in literature from different perspectives concerning *what it is* (Alavi & Leidner, 2001; Holsapple, 2005; Lin & Ha, 2015), *where it is embedded* (Dalkir, 2013) and *how it can be classified* (Holsapple, 2005; Nonaka, 1994; Polanyi, 2015). Taking a cue from the above literature, the organisation's knowledge is a multifaceted entity as it shows itself simultaneously as a stock and as a flow (Bolisani & Oltramari, 2012; Bratianu & Bejinaru, 2019; Weick, 1995). As stock (KS), it is incorporated in specific components (Figure a):

- *human resources (HR),* including all the person-embedded knowledge, namely the whole set of human skills, human know-how, emotional knowledge, personal values
- *hardware (HA),* including all knowledge embodied in objects, products, tools, equipment, and information systems
- *information (IN),* including the knowledge in the form of ideas and information recorded in manuals, articles, licences, patents, memoranda and any other written documentation
- *organisational rules (OR),* including all knowledge in procedures, routines, organisation culture, and organisational linkages.

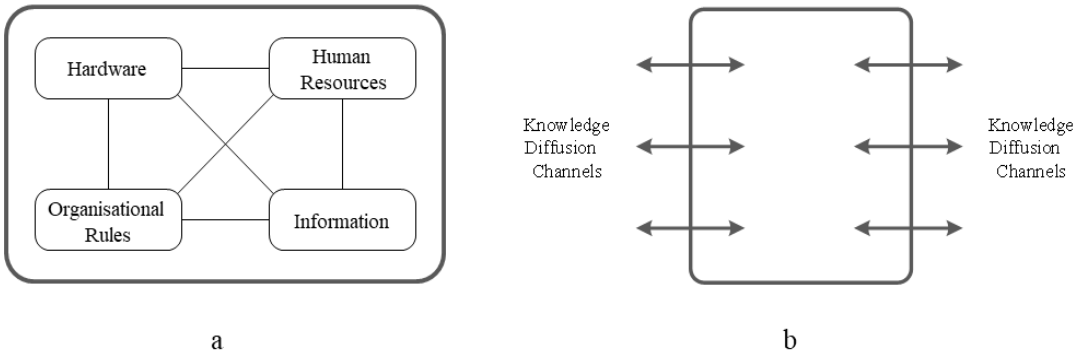


Figure 16 Knowledge nature: as a stock (a) and as a flow (b)

As a flow, it develops through the relationships with other organisations, customers, suppliers, service providers, universities, research centres/laboratories, institutions, and markets and necessitates defining the specific case. From this point of view, the organisation's channels to communicate with the external environment are proper vehicles of knowledge diffusion. They are channels of knowledge diffusion (CKD) through which the organisation gives and receives knowledge (Figure 6b). Knowledge as stock and knowledge as flow are two reciprocal sides of organisation knowledge. Knowledge as flow is transformed into knowledge as stock (and so into the organisation's knowledge) through a process of *sensemaking* (Bolisani & Oltramari, 2012; Bratianu & Bejinaru, 2019; Weick, 1995), which is the ability of the organisation to give meaning to the data and information conveyed by the channels of communication with the external environment, and *sharing* within the organisation through processes of socialisation, externalisation, internalisation, and combination (Nonaka, 1994). This process of sensemaking and sharing requires a KS capable of interpreting, contextualising, and sharing the contents of the CKD with the external environment. In other words, the ability of an organisation to transform knowledge as flow into KS depends, in turn, on the

knowledge as stock itself (Martins et al., 2022; Wang et al., 2009). Without the KS, the process of sensemaking and sharing is not activated. For example, the customer's suggestions on quality control could allow the supplier to acquire new procedures and organisational rules, enriching knowledge as stock. Nevertheless, if the supplier is not able to catch the customer’s suggestions (e.g., different languages, different culture), the process of sensemaking does not take place and does not improve KS (Prior et al., 2018). Indeed, the ability of a supplier to operate with computer-based technologies (KS) allows interfacing with customers through digital channels that provide an excellent capability to give and receive information and then a knowledge as flow. In synthesis, knowledge as flow creates knowledge as stock and knowledge as stock creates knowledge as flow. Therefore, knowledge as stock and knowledge as flow are reciprocal dimensions: one reinforces the other and one does not exist without the other (Venkatraman & Tanriverdi, 2004).

Starting from the above conceptual schema, the problem of knowledge diffusion in the supply chain consists of analysing how knowledge flows from the customer to FTS and from FTS to STS. For this reason, the unit of analysis includes the triadic relationship between the customer, FTS and STS. Furthermore, the unit of analysis is represented by the four components of KS and CKD (Figure).

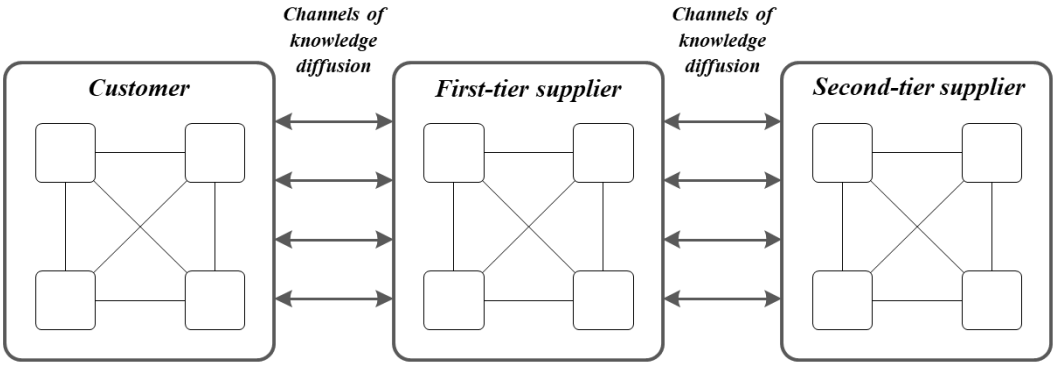


Figure 17 The unit of analysis

Analysing the channels of knowledge diffusion allows us to specify the particular flow of knowledge that develops in the supply chain. Thanks to these CKD, FTS and STS enrich their knowledge asset (KS). In this way, the technological distance between customers and suppliers is reduced and a process of quasi-integration between members within the supply chain is activated (Colombo & Mariotti, 1998; E. Esposito & Raffa, 1994; Patrucco et al., 2022).

Following this premise, the analysis of knowledge diffusion between members of the supply chain includes two problems:

1) Evaluate how the CKD, generated by the relationship between customers and FTS, feed the four components of KS (hardware, human resources, information, and organisational rules) that, in turn, feed the FTS knowledge,

2) Evaluate how the CKD, generated by the relationship between FTS and STS, feed the four components of KS that feed the STS knowledge.

They are two multi-criteria evaluation problems that, in turn, involve three issues:

1) Evaluate the intensity of use of each CKD,

2) Evaluate the importance (weight) of each CKD for each of the four components of KS,

3) Evaluate the importance of each KS component (weight) concerning the supplier knowledge.

5.3 Methodology

In order to deal with these issues, a hybrid model is proposed based on two main approaches suggested in the literature to address these problems: the Analytic Hierarchy Process (AHP) and the Fuzzy Set Theory (FST).

The AHP-based approach is suitable for weight determination (Bruno et al., 2012; Saaty, 1984). In the proposed model, AHP is used to evaluate the relative importance of each CKD concerning each KS component and evaluate the importance of each KS component. FTS is relevantly suitable for performance estimations where it is necessary to capture the nuance and imprecision of human judgments (Zadeh, 1965; Zimmermann, 2001). In this proposed model, FTS is used to identify the intensity of each CKD for each relationship (customer/FTS and FTS/STS). The proposed model is based on four general steps (S1, S2, S3 and S4), six steps related to the AHP approach for the identification of the weights of the channels and components of knowledge (AHP1.1, AHP2.1, AHP3.1, AHP1.2, AHP2.2, AHP3.3) and three steps concerning the FST for the evaluation of the intensity of use of each CKD (FST1, FST2, FST3) (Figure).

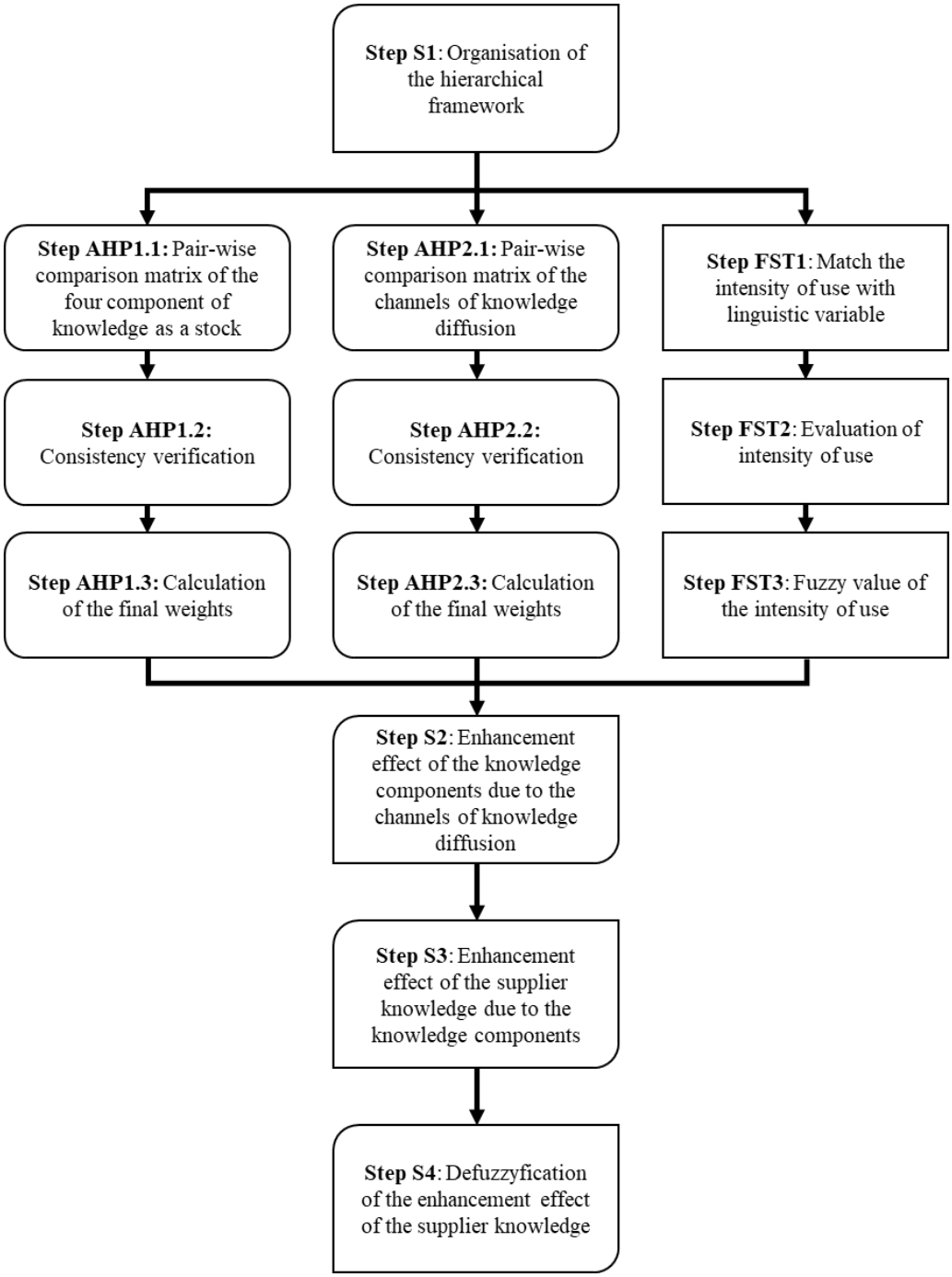


Figure 18 Flowchart of the hybrid AHP-FST model

Step S1 - Organisation of the hierarchical framework

This step organises the knowledge components of KS and CKD in a hierarchical framework.

Step AHP1.1 - Pair-wise comparison matrix of the four components of knowledge as stock

The relative importance of each element concerning the others at the same level of the hierarchy is evaluated using Saaty's scale. The eigenvalues $\lambda_{i=1,\ldots,N}$ identification is used to identify the pair-wise comparison matrix and produce the priority vectors for each N component.

Step AHP1.2 - Consistency verification

Each pair-wise comparison matrix's consistency is checked. Specifically, for each matrix, the eigenvalues are determined, and, considering the eigenvalue with the highest value, the consistency ratio (CR) is calculated as a ratio between the consistency index (CI), defined in equation 1, and the random index (RI) defined in equation 2.

$$CI=(\lambda_{Max}-N)\ /(N-1)$$ (Equation 1)

$$CR=CI/RI$$ (Equation 2)

Step AHP1.3 - Calculation of the final weights

When the matrix consistency is confirmed, the weights of the four knowledge components as stock are determined. According to Saaty (1980), the weights are identified by the eigenvectors associated with the highest eigenvalue and then normalised.

AHP2.1, AHP2.2, and AHP2.3 are comparable to AHP1.1, AHP1.2, and AHP1.3, but they focus on channels of knowledge diffusion rather than knowledge as stock. The weight of the channels of knowledge diffusion is thus identified for each component of knowledge.

Step FST1 - Correlate use intensity with linguistic variables

The intensity of use of CKD is specified as a linguistic variable: very poor (VP), poor (PO), medium (ME), important (IM), and very important (VI).

Step FST2 - Intensity of usage evaluation

Following the identification of linguistic variables, the intensity of use of each CKD is assessed.

Step FST3 - Fuzzy intensity of use-value

The intensity of use of each CKD is translated into a fuzzy number through the fuzzy term set.

Step S2 - Enhancement effect of the knowledge components

Aggregating the weights of the CKD (Step AHP.3) with the fuzzy values of their intensity of usage (Step FST3) to identify how they feed each component of KS, that is the enhancement effect of the knowledge component.

Step S3 - Enhancement effect of the supplier knowledge

The crisp weight of the KS components (Step AHP1.3) is combined with the fuzzy value of their enhancing effect (Step FST2) to determine the influence on supplier knowledge (enhancement effect of supplier knowledge).

Step S4 - Defuzzification of the supplier knowledge's enhancing effect

Finally, the fuzzy value of the supplier knowledge enhancement impact is defuzzified. As a result, an index ranging from 0 to 100 is produced. If the intensity of usage of the CKD is very low, the value is close to zero; hence, the connection does not create significant knowledge diffusion. On the other hand, if the intensity of usage of all the CKD involved in the relationship is very high, the value is close to 100, and the enhancing effect of the supplier knowledge owing to the relationship is quite high. The usefulness of the hybrid model in supply chain practices is studied using a sample of 18 triadic relationships described in the following sections. The proposed model is applied twice for each of the 18 triadic relationships. In the first phase, the model evaluates the FTS knowledge enhancement effect and the interaction between the customer and the FTS. In the second phase, the model investigates the STS knowledge enhancement effect, the relationship between FTS and STS. This approach highlights the knowledge diffusion process from customer to STS through the FTS.

5.3.1 Sample and investigation methodology

The analysis was conducted in Italy on a sample of 18 triadic relationships involving FTSs operating in high-tech and/or complex industries such as aerospace and automotive. The sample includes 5 triadic relationships in the aerospace sector (27.8%) and 13 triadic relationships in the automobile industry (72.2%).

Semi-structured interviews were conducted to investigate 36 relationships, namely 18 between the customer and the FTS and 18 between the FTS and the STS.

The semi-structured interview approach has the advantage of having a plot of pre-established questions without limiting respondent answers and allowing them to add further details (Qu & Dumay, 2011). The investigation process entails three main phases:

1) Definition of the core research objectives and preliminary semi-structured questionnaire creation. A prior version of the semi-structured questionnaire was developed during this phase, beginning with the investigation's primary goals.

2) Test of the semi-structured questionnaire. The semi-structured questionnaire was tested in this step by conducting three pilot interviews with three FTSs. Based on the feedback, the semi-structured questionnaire was improved.

3) Field examination. This phase consists of distributing the questionnaire for each supply chain face-to-face to two FTS managers with different abilities and duties. This enabled us to gain insight into the relationship with both the customers and the STS.

5.3.2 Model implementation

In this section, the proposed hybrid model is implemented and for each step, it is described how it was performed. To deal with this step, a panel of experts operating in the supply

chain, consisting of managers of customers, FTS, STS, and university researchers with multi-year expertise in the field of supply chain management.

Thanks to the panel of experts, six main channels were identified: Materials and semi-finished products (Ma); Tools, equipment and facilities (To); Customer-directed training (Tr); Inspection visits, suggestions or actions of the customer (Vi); Documents/Information (papers, electronic sheets, documents on computer support) (Do); and Collaborations at the beginning of the contract and in progress (Co). Subsequently, these six channels of knowledge diffusion and the four components of the knowledge as stock were organised in a hierarchical framework (Figure a).

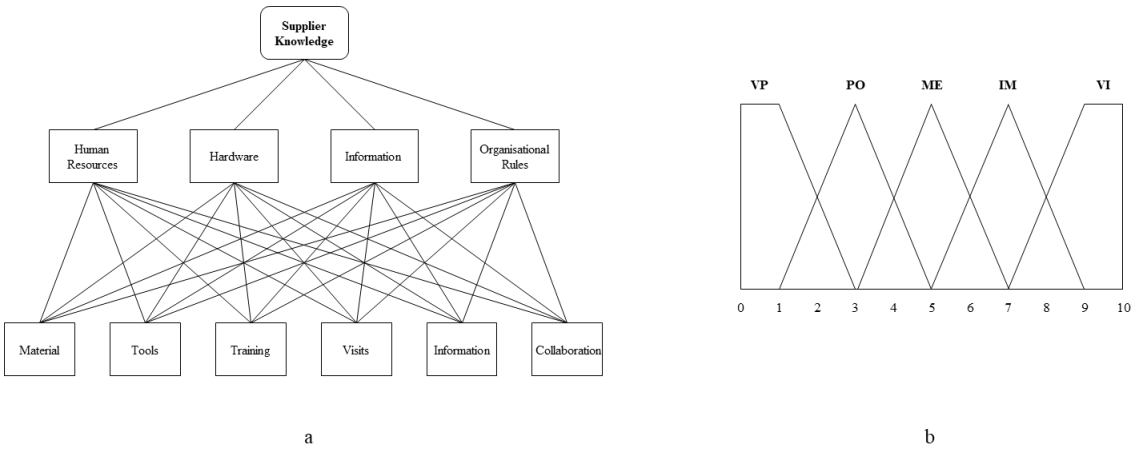


Figure 19 The frameworks used: the hierarchical framework (a) and the fuzzy term set (b)

Each of the 18 FTSs was asked to provide a judgement (according to Saaty's scale in Figure b) relative to the importance of each knowledge component concerning the others. The result was a set of 18 pair-wise comparison matrices. In this step, for each of the 18 pair-wise comparison matrices (Step AHP1.1) was first identified the principal eigenvalue

and then verified the consistency of the matrix through the CR. For instance, considering supplier A4, the principal eigenvalue λ_{Max} = 4.15, CI = 0.0515, RI = 0.89, and CR = 0.0579. This last value is less than 0.10 and assures that the consistency is verified. Once each matrix consistency was verified, the eigenvector associated with the principal eigenvalue was calculated and then normalised to identify the weights of the four components of knowledge of each of the 18 FTSs (Table 8).

Table 8 Weights of the four components of knowledge of the FTS and of the channels of knowledge diffusion of the FTS

FTS	HR				HA			IN				OR		
	KS	CKD			KS	CKD		KS	CKD			KS	CKD	
		Tr	Vi	Co		Ma	To		Do	Vi	Co		Vi	Co
A1	0.54	0.14	0.43	0.43	0.18	0.50	0.50	0.18	0.43	0.14	0.43	0.10	0.50	0.50
A2	0.67	0.09	0.45	0.45	0.14	0.50	0.50	0.14	1.62	0.13	0.45	0.06	0.75	0.25
A3	0.20	0.64	0.26	0.10	0.18	0.17	0.83	0.56	0.75	0.12	0.13	0.06	0.83	0.17
A4	0.17	0.33	0.33	0.33	0.10	0.50	0.50	0.12	0.13	0.12	0.75	0.61	0.88	0.13
A5	0.35	0.66	0.19	0.16	0.12	0.50	0.50	0.29	0.66	0.19	0.16	0.24	0.50	0.50
A6	0.38	0.43	0.43	0.14	0.38	0.50	0.50	0.13	0.20	0.60	0.20	0.13	0.75	0.25
A7	0.13	0.65	0.22	0.13	0.38	0.75	0.25	0.38	0.79	0.07	0.15	0.13	0.75	0.25
A8	0.52	0.45	0.09	0.45	0.20	0.25	0.75	0.08	0.09	0.45	0.45	0.20	0.83	0.17
A9	0.42	0.73	0.19	0.08	0.42	0.75	0.25	0.08	0.45	0.45	0.09	0.08	0.83	0.17
A10	0.65	0.10	0.26	0.64	0.19	0.83	0.17	0.10	0.60	0.08	0.32	0.06	0.50	0.50
A11	0.38	0.33	0.33	0.33	0.38	0.50	0.50	0.13	0.33	0.33	0.33	0.13	0.50	0.50
A12	0.66	0.43	0.43	0.14	0.08	0.88	0.13	0.19	0.45	0.09	0.45	0.08	0.75	0.25
A13	0.17	0.64	0.10	0.26	0.17	0.50	0.50	0.05	0.07	0.28	0.65	0.62	0.50	0.50
A14	0.10	0.07	0.28	0.65	0.10	0.83	0.17	0.56	0.06	0.21	0.74	0.25	0.83	0.17
A15	0.10	0.09	0.45	0.45	0.10	0.83	0.17	0.56	0.33	0.33	0.33	0.25	0.83	0.17
A16	0.09	0.07	0.22	0.71	0.09	0.50	0.50	0.21	0.14	0.14	0.71	0.61	0.83	0.17
A17	0.13	0.62	0.30	0.09	0.20	0.50	0.50	0.57	0.52	0.28	0.21	0.10	0.83	0.17
A18	0.38	0.20	0.20	0.60	0.38	0.50	0.50	0.13	0.43	0.14	0.43	0.13	0.50	0.50

As for the relationship with the customer, each of the 18 FTSs was asked to provide a judgment (according to Saaty's scale) about the compared importance of each CKD for each of the four KS components. The result was 18 groups of 4 pair-wise comparison matrices for 72 matrices. For each FTS, a pair-wise comparison matrix for each of their four knowledge components. In this step, for each FTS was verified the consistency of the four pair-wise comparison matrices. Specifically, similarly to step AHP1.2, each matrix first identified the principal eigenvalue and then calculated the consistent ratio as a ratio between the CI and the RI. Once for each of the FTSs the consistency of each matrix was verified. Next, the eigenvectors associated with the four principal eigenvalues of each matrix were calculated and then normalised to identify the weights of the CKD concerning each component of knowledge (Table 8). At the end of this step, the weights of all the components of the hierarchical framework of the proposed hybrid model were identified for each FTS. An example relative to supplier A4 is in Figure .

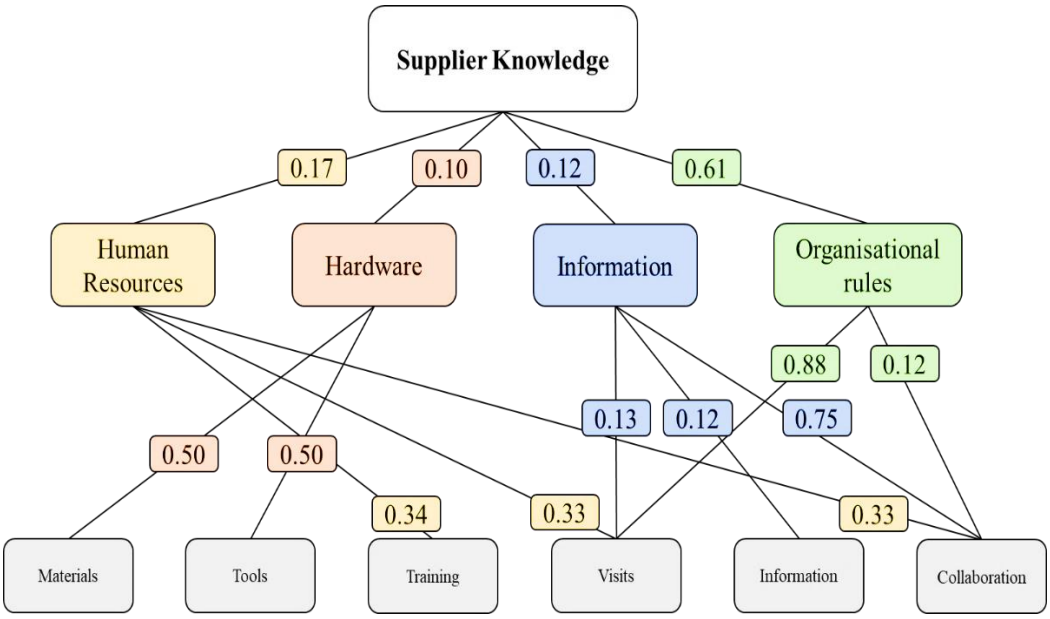


Figure 19 The hierarchical framework of the supplier A4

The intensity of use of CKD is defined as a linguistic variable and each of the 18 FTSs of the sample was asked, regarding the relationship with the customer, a judgment (ranging from very poor to very important) on each CKD (Table 9). For each FTS, the judgement of the intensity of use of each CKD identified as a linguistic variable is translated into the corresponding fuzzy number.

Table 9 The intensity of use of the CKD between customer and FTS and relative Fuzzy values

FTS	**Tr**		**Vi**		**Co**		**Ma**		**To**		**Do**	
A1	ME	(3,5,5,7)	ME	(3,5,5,7)	PO	(1,3,3,5)	ME	(3,5,5,7)	ME	(3,5,5,7)	ME	(3,5,5,7)
A2	VP	(0,0,1,3)	VP	(0,0,1,3)	VP	(0,0,1,3)	VP	(0,0,1,3)	VI	(7,9,9,10)	VI	(7,9,9,10)
A3	PO	(1,3,3,5)	VP	(0,0,1,3)	ME	(3,5,5,7)	IM	(5,7,7,9)	VI	(7,9,9,10)	IM	(5,7,7,9)
A4	VI	(7,9,9,10)	PO	(1,3,3,5)	PO	(1,3,3,5)	ME	(3,5,5,7)	PO	(1,3,3,5)	ME	(3,5,5,7)
A5	PO	(1,3,3,5)	IM	(5,7,7,9)	PO	(1,3,3,5)	ME	(3,5,5,7)	ME	(3,5,5,7)	ME	(3,5,5,7)
A6	IM	(5,7,7,9)	IM	(5,7,7,9)	ME	(3,5,5,7)	IM	(5,7,7,9)	ME	(3,5,5,7)	ME	(3,5,5,7)
A7	VI	(7,9,9,10)	IM	(5,7,7,9)	VP	(0,0,1,3)	ME	(3,5,5,7)	ME	(3,5,5,7)	PO	(1,3,3,5)
A8	VI	(7,9,9,10)	VI	(7,9,9,10)	VP	(0,0,1,3)	IM	(5,7,7,9)	IM	(5,7,7,9)	VI	(7,9,9,10)
A9	VI	(7,9,9,10)	IM	(5,7,7,9)	ME	(3,5,5,7)	ME	(3,5,5,7)	IM	(5,7,7,9)	PO	(1,3,3,5)
A10	VI	(7,9,9,10)	PO	(1,3,3,5)	VP	(0,0,1,3)	IM	(5,7,7,9)	IM	(5,7,7,9)	ME	(3,5,5,7)
A11	ME	(3,5,5,7)	ME	(3,5,5,7)	ME	(3,5,5,7)	IM	(5,7,7,9)	VI	(7,9,9,10)	IM	(5,7,7,9)
A12	VI	(7,9,9,10)	IM	(5,7,7,9)	PO	(1,3,3,5)	ME	(3,5,5,7)	ME	(3,5,5,7)	ME	(3,5,5,7)
A13	VP	(0,0,1,3)	ME	(3,5,5,7)	ME	(3,5,5,7)	IM	(5,7,7,9)	PO	(1,3,3,5)	VI	(7,9,9,10)
A14	VI	(7,9,9,10)	ME	(3,5,5,7)	VP	(0,0,1,3)	ME	(3,5,5,7)	IM	(5,7,7,9)	PO	(1,3,3,5)
A15	IM	(5,7,7,9)	VI	(7,9,9,10)	VP	(0,0,1,3)	IM	(5,7,7,9)	PO	(1,3,3,5)	PO	(1,3,3,5)
A16	VI	(7,9,9,10)	IM	(5,7,7,9)	VP	(0,0,1,3)	ME	(3,5,5,7)	ME	(3,5,5,7)	ME	(3,5,5,7)
A17	ME	(3,5,5,7)	ME	(3,5,5,7)	ME	(3,5,5,7)	PO	(1,3,3,5)	PO	(1,3,3,5)	IM	(5,7,7,9)

Following the flowchart indicated in Figure 18, for each FTS and each component of KS, the weights of the CKD (step AHP2.3) were aggregated with the value of their intensity of use (step FST3). The result was four fuzzy numbers for each FTS representing how the CKD feeds the four components of KS (enhancement effect of knowledge components). For each FTS, the weights of the four KS components (step AHP1.3) were aggregated

with the enhancement effect of knowledge components (step S2). The result was a fuzzy number that depicts for each FTS how the CKD, through the knowledge components, feed the FTS knowledge (knowledge enhancement effect of supplier) (Table 10). Finally, the fuzzy value of the knowledge enhancement effect of FTS was defuzzified using the well-known mean-of-maxima method. The result was an index that ranges from a value near 0 to a value near 100, which represents for each FTS the crisp value of the knowledge enhancement effect generated by the relationship with the customer (Table 10). Once identified the knowledge enhancement effect of FTS due to the relationship with the customer (first phase of model implementation), focusing on the relationship between FTS and STS and repeating the procedure from Step S1 to Step S4, it was evaluated for each STS, the value of the knowledge enhancement effect generated by the relationship with the FTS (second phase of the model implementation). The synthesis of also this second phase results is shown in Table 10.

Table 10 Enhancement effect of FTS and STS knowledge

	FTS		STS	
	Fuzzy value	Crisp value	Fuzzy value	Crisp value
A1	(2.85, 4.85, 4.85, 6.85)	4.85	(3.47, 5.47, 5.47, 7.47)	5.47
A2	(3.03, 3.90, 4.87, 5.93)	4.43	(2.25, 3.16, 3.67, 5.60)	3.67
A3	(4.73, 6.42, 7.01, 8.14)	6.57	(4.02, 6.02, 6.05, 7.99)	6.02
A4	(2.84, 4.84, 4.89, 6.79)	4.84	(4.31, 6.22, 6.26, 8.26)	6.26
A5	(2.55, 4.57, 4.57, 6.59)	4.57	(1.83, 3.85, 3.85, 5.87)	3.85
A6	(4.31, 6.31, 6.31, 8.31)	6.31	(4.20, 6.20, 6.36, 8.04)	6.2
A7	(3.89, 5.73, 6.09, 7.53)	5.81	(2.89, 4.56, 5.01, 6.44)	4.73
A8	(4.35, 5.88, 6.38, 7.85)	6.12	(1.80, 3.33, 3.61, 5.51)	3.56
A9	(4.61, 6.73, 7.04, 8.52)	6.73	(3.88, 5.84, 6.23, 7.72)	5.92
A10	(4.73, 6.59, 6.82, 8.50)	6.66	(4.79, 6.79, 7.27, 8.32)	6.79
A11	(4.33, 6.33, 6.50, 8.17)	6.33	(4.13, 6.13, 6.31, 7.94)	6.13

A12	(2.84, 4.91, 4.98, 6.92)	4.91	(1.41, 2.64, 3.13, 5.07)	3.06
A13	(4.71, 6.55, 6.97, 8.29)	6.63	(5.40, 7.40, 8.09, 8.72)	7.4
A14	(2.75, 5.07, 5.15, 7.33)	5.07	(2.42, 4.75, 4.83, 7.01)	4.75
A15	(3.32, 5.64, 5.66, 7.96)	5.65	(3.38, 5.72, 5.80, 7.97)	5.72
A16	(3.25, 5.24, 5.29, 7.20)	5.24	(1.63, 3.61, 3.66, 5.58)	3.62
A17	(2.43, 4.56, 4.56, 6.70)	4.56	(2.75, 4.89, 4.89, 7.02)	4.89
A18	(4.06, 6.06, 6.06, 8.06)	6.06	(3.61, 5.61, 5.69, 7.54)	5.61

5.4 Discussion of results

The findings allow us to identify four different supply chain behaviours. A high (low) value of the knowledge enhancement effect of the FTS means high (low) diffusion of knowledge from the customer to the FTS. Similarly, a high (low) value of the knowledge enhancement effect of the STS means high (scarce) diffusion of knowledge from the FTS to the STS. In this section, the two effects are used together to highlight the role of a FTS within the supply chain. Using these two effects, it is possible to identify four areas limited by their average value that is 5.63 for the knowledge enhancement effect of the FTS and 5.20 for the knowledge enhancement effect of the STS (Figure). It is possible to identify four areas. High-right area is characterised by a high level of diffusion of knowledge from the customer to the FTS and from FTS to the STS (area A1). In the high-left area the level of diffusion of knowledge from the customer to the FTS is low while the level of diffusion of knowledge from FTS to the STS is high (area A2). Low-left area is characterised by a low level of diffusion of knowledge from the customer to the FTS and from the FTS to the STS (area A3). Low-right area is characterised by a high diffusion of knowledge from customer to the FTS while low diffusion of knowledge from FTS to the STS is low (area A4). These four areas identify the different behaviours of FTS within the supply chain.

The A1 area is particularly important. This is the area where the relationship between customer and FTS is based on an intensive flow of knowledge. The FTS intercepts an intense flow of knowledge by the customer and conveys an intense flow of knowledge to the STS. These FTSs play a crucial role in knowledge diffusion within the supply chain. Customers can leverage these FTSs to model and develop their supply system. This is the *Hub supplier* area. In this area are located 8 out of 18 FTSs of the sample analysed. In the A2 area the relationship between customers and FTS is based on a moderate flow of knowledge. The FTSs do not receive an intense flow of knowledge from the customer but convey an intense flow of knowledge to the STS. They play an important role in the supply system as they are a source of knowledge and facilitate its diffusion down the supply chain. This is the *Source supplier* area. Only 2 out of 18 FTSs of the sample are included in this area. The A3 area is particularly critical. This is the area where the relationship between customers and FTS is based on a moderate flow of knowledge. The FTSs intercept a weak flow of knowledge by the customer and convey a weak flow of knowledge to the STS. They do not play an important role in the process of knowledge diffusion within the supply chain. Customers cannot take full advantage of these FTS to model and develop their supply system. This is the *Restrain supplier* area. In this area are located 6 out of 18 FTSs of the sample. In the A4 area, the customer and FTSs is based on a high flow of knowledge. The FTSs receive an intensive flow of knowledge by the customer but convey a low flow of knowledge to the STS. They are knowledge sponges that absorb the customer's intense flow of knowledge but do not facilitate its diffusion down the supply chain. This is the *Sponge supplier* area. This area encompasses 2 out of 18 FTSs of the sample. The taxonomy in Figure 21 highlights that there are various roles and behaviours of the FTSs within the supply chain.

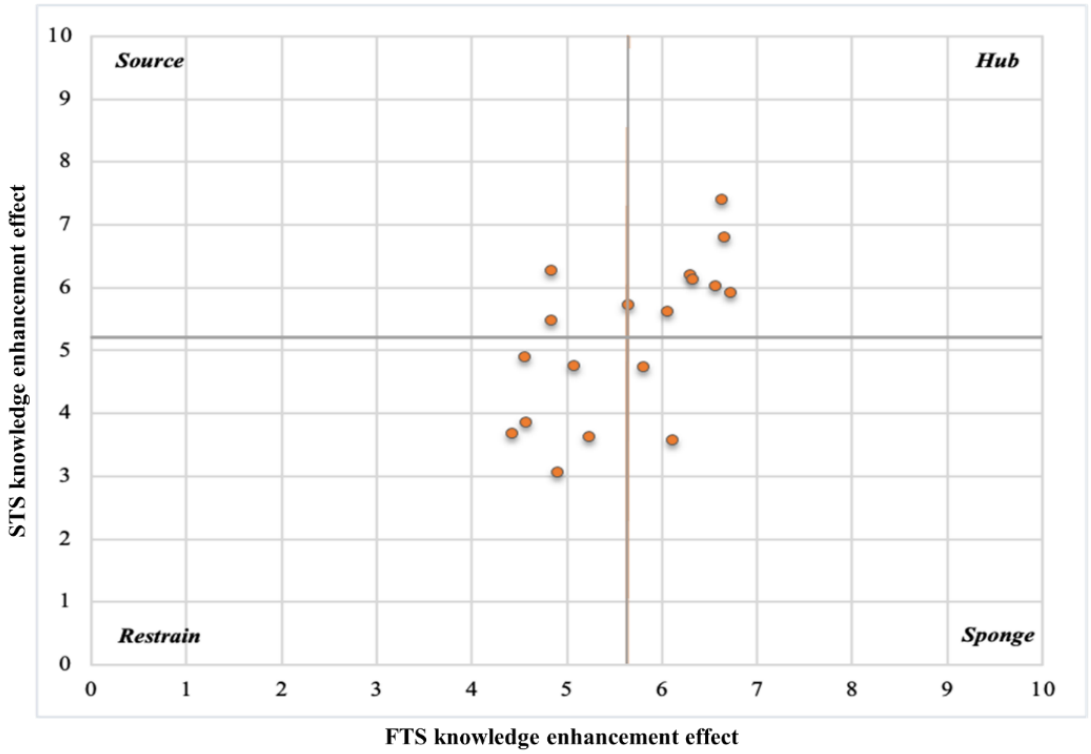


Figure 20 Taxonomy of FTS

5.5 Conclusion and implications

This paper has highlighted that an organisation's knowledge is multifaceted since it is simultaneously a stock and a flow. It is incorporated in specific components like hardware, human resources, information, and organisational rules as stock. As a flow, it develops through relationships with other organisations, customers, suppliers, service providers, universities, research centres/laboratories, institutions, and markets. Knowledge as a flow creates knowledge as a stock, and knowledge as a stock creates knowledge as a flow. Therefore, knowledge as a stock and knowledge as a flow is reciprocal by nature, one reinforces the other and one does not exist without the other. Starting from the organisation knowledge concept, the paper has stressed that knowledge diffusion in the supply chain consists in analysing how knowledge flows from customer

to first-tier supplier and from first-tier supplier to second-tier supplier. In this paper, a hybrid model that interprets the diffusion of knowledge within the triadic relationship between the customer, first-tier supplier and second-tier supplier was proposed to deal with this issue. The proposed hybrid model is based on the Analytic Hierarchy Process and the Fuzzy Set Theory. The effective usability of the hybrid model was investigated through a sample of 18 triadic supply chain relationships. For each of the 18 triadic relationships, the proposed model was implemented twice: firstly, to evaluate the knowledge enhancement effect of the first-tier supplier according to the customer relationship, and secondly to evaluate the knowledge enhancement effect of the second-tier supplier according to the first-tier supplier relationship. In this way, it highlighted the process of knowledge diffusion inside the supply chain from customer to first-tier supplier to second-tier supplier. Finally, based on the two enhancement effects, a taxonomy explanatory of the role and behaviour of first-tier suppliers within the supply chain was identified. Four areas were highlighted: *Hub supplier* area, *Source supplier* area, *Restrain supplier* area, and *Sponge supplier* area.

In the *Hub supplier* area, the first-tier supplier intercepts the customer's intense flow of knowledge and conveys a high flow of knowledge to the second-tier supplier. These first-tier suppliers play a crucial role in knowledge diffusion within the supply chain.

In the *Source supplier* area, the first-tier supplier does not receive an intense flow of knowledge from the customer but conveys a high flow of knowledge to the second-tier supplier. Therefore, they play an essential role in the supply system as they are a source of knowledge and facilitate its diffusion across the supply chain.

In the *Restrain supplier* area, the first-tier supplier intercepts a weak flow of knowledge and conveys a poor flow of knowledge to the second-tier supplier. Therefore, they do not play an essential role in knowledge diffusion within the supply chain.

In the *Sponge supplier* area, the first-tier supplier receives an intensive flow of knowledge from the customer but conveys a low flow of knowledge to the second-tier supplier. This is because they are natural sponges that absorb the customer's intense flow of knowledge but do not facilitate its diffusion across the supply chain.

The taxonomy developed in this paper may have implications for customers and suppliers. From a customer's point of view, *hub suppliers* and *source suppliers* are critical in guiding the supply system development process. To improve the supply system, the customer should encourage the expansion of these suppliers, which will lead to the growth of the second-tier supplier network. Such systems would undoubtedly produce outputs that are more closely aligned with the customer's needs. In terms of the first-level suppliers, this contribution proposes a taxonomy that can be used to identify the most appropriate strategies to improve own level of competitiveness, in comparison to other suppliers, within the customer's supply system, managing to break down costs, and improving the quality of the final output both for the customer and for the market share growth prospects.

On the other hand, *restraint suppliers* and *sponge suppliers* characterise supply chains that should be re-engineered, at least in their first-tier supplier component. This type of supply chain obstructs the flow of knowledge along the supply chain, resulting in a decrease in the perceived quality of the final product by the customer, a higher cost of this output due to inefficiencies in business processes, and a general stagnation of the

economic development of the territory in which they operate due to a lack of innovations linked to a lack of knowledge spread. A first step in reengineering would be to start with the supplier's hierarchical framework and reallocate the resources available to maximise the efficiency of the knowledge diffusion that the supplier already has at its own disposal, based on the channels that would bring the greater added value of knowledge if more supported.

Even though deployed on specific sectors, the suggested model and methodology can be simply applied to other industries by determining the appropriate knowledge diffusion channels for each industry and then applying the AHP-Fuzzy methodology upstream and downstream of the FTS. Among the limitations of this research, the proposed taxonomy was created by excluding the variable of the technological level owned by the various companies interviewed during the model construction process to have a clear overview of knowledge dynamics. As a result, additional analyses will be conducted to evaluate how technology impacts the supply chain's triadic relationship and how these impacts align with the results found in this contribution.

6 CONCLUDING REMARKS

The present thesis consisted of an analysis of how knowledge management has evolved and changed with the advent of digital solutions of the latest digital revolutions and a study of mixed methods involving both qualitative and quantitative research methodologies. By doing so, he contributed to the theory of knowledge management and knowledge creation as well as the theory of digitization. The resulting findings offer significant insights to practitioners as well as policy makers, as illustrated below.

This doctoral thesis has offered both theoretical and practical contributions.

6.1 Conclusion to theory and practice

From the theoretical point of view, the tertiary review provides a unique compendium of search directions to offer a comprehensive overview of the scientific debate about knowledge management. The significant amount of primary and secondary studies published on knowledge management issues in recent years justified the need for this tertiary study. By considering the key assumptions underlying the knowledge management theory, it was highlighted the shortcomings stemming from it, and it was advanced alternative assumptions having the potential to improve the extant theory and at paving new ways to conceptualize and consider knowledge management. Taking a cue from the digital knowledge research, the actual comprehension of digital knowledge has been drawn through the bibliometric analysis of the existing literature. From this analysis, it emerged how in theory, a new knowledge framework is arising: the new digital solutions of the last years pushed the shift of digital devices from simple support tools to

autonomous actors in the knowledge management model. In this way, the SECI model proposed by Nonaka and Takeuchi explains only two of the three ontological dimensions of knowledge, while the WISED model tries to complete the SECI model, also explaining the digital dimension.

Through the empirical study conducted in the third analysis, the attempt to contribute to the knowledge management literature continued testing how the new pattern of digital knowledge is used and implemented in reality. Organisations adopting agile innovation practices were chosen to test the theoretical model. It is necessary to underly that knowledge management is one of the pillars of the agile innovation paradigms, so during the interviews, it was tested not only the adoption of new knowledge management practices but also new agile innovation ones. This supported also the debate about how cutting-edge technologies can support and modify actual business and supply chain models, considering that agile innovation try to shift the organisation to have a network perspective. Finally, among the most important contributions of the present dissertation is the new analysis perspective of the supply chain. Generally, the dyadic relationship between customers and first-tier-supplier is considered, while now also the second-tier supplier is considered to better understand the dynamics of knowledge diffusion in the supply chain. Adopting a quantitative analysis with a hybrid method (analytical hierarchy process and fuzzy set theory) it was evaluated knowledge diffusion in complex and high-tech fields that represent very relevant cases in the knowledge management debate. It was obtained a relevant taxonomy classifying first-tier suppliers according to the knowledge diffusion flow.

The present doctoral dissertation only partially covers the underlined research problems and gaps. However, there is the hope that this contribution has offered significant insights for future research to take further steps in extending and improving the knowledge management field and the growing digitalising field from all theoretical, methodological, and empirical points of view.

It would be prudent for managers and practitioners to explore how KM systems can affect economic, environmental, and social performance indicators. In fact, the study provides managers with a variety of viewpoints that allow them to reap the benefits of KM in their processes and operations. The bibliometric information on KM reviews is extremely valuable to managers because it helps them to pinpoint the worldwide KM experience. In addition, the findings reveal management implications on the cultural aspect of the organisation. People, workers, and managers are the most important aspect of KM processes because they are the knowledge holders (Caputo et al., 2021; Magni et al., 2021b; Navarro et al., 2010; Thomas et al., 2001). In particular, tacit knowledge lies in the experience and behaviours of the organization's members. Therefore, the cultural dimension is of the utmost importance: not only is it necessary to provide increasingly intuitive and user-friendly tools for capturing, organising, and disseminating information, but also to share the same corporate vision and be in agreement that knowledge is a key asset for creating value (Cerchione et al.,2016; Khan and Vorley, 2017).

In the era of digital transition, the bibliometric overview provides potential for practitioners and organisations engaged in KM. In reality, it gives managers with a variety of technology perspectives that enable them to enjoy the benefits of KM in their work. The bibliometric information regarding the KM literature is of great importance to

managers since it enables them to identify the worldwide KM expertise. Thus, digital KM research initiatives can be built with this understanding in mind.

In addition, the use of Industry 4.0 technologies, especially software technology and social media platforms, is crucial for accurately digitising corporate operations. Improving coordination and collaboration in KM processes has the potential to provide enormous economic benefit in today's more interconnected society. Such integrated technologies may be a crucial tool for a more open and collaborative production culture, if not one of trust throughout the entire value chain, if they were also externally integrated. These software innovations will have a positive effect on all processes in which they are implemented. Possessing up-to-date information enables businesses to effectively respond to unforeseen internal needs related to the highly changeable customer and market demand. Furthermore, these technologies have a crucial effect on the transition processes between explicit and digital forms of knowledge. These technologies may quickly transform from one form to another and manage the activities involving these kinds of knowledge, including generation, acquisition, and storage.

In conclusion, it is possible to assert that digital knowledge has the potential to revolutionise all processes for which a digital tool can be associated, but that this must be managed differently than human-processed information. Different processing speeds and a larger volume of data managed in an antiquated knowledge management and human resources perspective may cause a misalignment between people and reality. Reason why the social sustainability of digital knowledge management methods requires additional human resource management and Industry 5.0-centric insights.

7 LIST OF FIGURES

8 LIST OF TABLES

9 REFERENCES

Abbas, J., & Sağsan, M. (2019). Impact of knowledge management practices on green innovation and corporate sustainable development: A structural analysis. *Journal of Cleaner Production*, *229*, 611–620. https://doi.org/10.1016/j.jclepro.2019.05.024

Acerbi, F., Sassanelli, C., Terzi, S., & Taisch, M. (2020). Towards a Data-Based Circular Economy: Exploring Opportunities from Digital Knowledge Management. In M. Rossi, M. Rossini, & S. Terzi (Eds.), *Proceedings of the 6th European Lean Educator Conference* (pp. 331–339). Springer International Publishing. https://doi.org/10.1007/978-3-030-41429-0_33

Akhavan, P., Ale Ebrahim, N., Fetrati, M., & Pezeshkan, A. (2016). Major trends in knowledge management research: A bibliometric study. *Scientometrics*, *107*, 1249–1264. https://doi.org/10.1007/s11192-016-1938-x

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly*, *25*(1), 107. https://doi.org/10.2307/3250961

Aleksander, I. (2017). Partners of Humans: A Realistic Assessment of the Role of Robots in the Foreseeable. *Journal of Information Technology*, *32*, 1–9. https://doi.org/10.1057/s41265-016-0032-4

Alexandru, V. A., Bolisani, E., Andrei, A. G., Cegarra-Navarro, J. G., Martínez Martínez, A., Paiola, M., Scarso, E., Vătămănescu, E.-M., & Zieba, M. (2020). Knowledge management approaches of small and medium-sized firms: A cluster analysis. *Kybernetes*, *49*(1), 73–87. https://doi.org/10.1108/K-03-2019-0211

Aljuwaiber, A. (2016). Communities of practice as an initiative for knowledge sharing in business organisations: A literature review. In *JOURNAL OF KNOWLEDGE*

MANAGEMENT (Vol. 20, Issue 4, pp. 731–748). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-12-2015-0494

Almeida, M., Freitas, C., & Souza, I. (2011). *Repositório Institucional da UFMG: Gestão do conhecimento em organizações: Proposta de mapeamento conceitual integrativo*. https://repositorio.ufmg.br/handle/1843/EARM-6ZGNE6

Alonso-Muñoz, S., González-Sánchez, R., Siligardi, C., & García-Muiña, F. E. (2021). Building Exploitation Routines in the Circular Supply Chain to Obtain Radical Innovations. *Resources*, *10*(3), Article 3. https://doi.org/10.3390/resources10030022

Anand, A., Muskat, B., Creed, A., Zutshi, A., & Csepregi, A. (2021). Knowledge sharing, knowledge transfer and SMEs: Evolution, antecedents, outcomes and directions. In *PERSONNEL REVIEW* (Vol. 50, Issue 9, pp. 1873–1893). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/PR-05-2020-0372

Andrade Rojas, M. G., Solis, E. R. R., & Zhu, J. J. (2018). Innovation and network multiplexity: R&D and the concurrent effects of two collaboration networks in an emerging economy. *Research Policy*, *47*(6), 1111–1124. https://doi.org/10.1016/j.respol.2018.03.018

Anwar, M., Scheffler, M. A., & Clauss, T. (2022). Digital Capabilities, Their Role in Business Model Innovativeness, and the Internationalization of SMEs. *IEEE Transactions on Engineering Management*, 1–13. Scopus. https://doi.org/10.1109/TEM.2022.3229049

Aoki, M. (1984). *The Co-operative Game Theory of the Firm*. Oxford University Press.

Apa, R., De Noni, I., Orsi, L., & Sedita, S. R. (2018). Knowledge space oddity: How to increase the intensity and relevance of the technological progress of European

regions. *Research Policy*, *47*(9), 1700–1712. https://doi.org/10.1016/j.respol.2018.06.002

Aparicio, M., Oliveira, T., Bacao, F., & Painho, M. (2019). Gamification: A key determinant of massive open online course (MOOC) success. *Information & Management*, *56*(1), 39–54. https://doi.org/10.1016/j.im.2018.06.003

Ardito, L., Cerchione, R., Mazzola, E., & Raguseo, E. (2021). Industry 4.0 transition: A systematic literature review combining the absorptive capacity theory and the data–information–knowledge hierarchy. *Journal of Knowledge Management*. Scopus. https://doi.org/10.1108/JKM-04-2021-0325

Arena, S., Florian, E., Zennaro, I., Orrù, P. F., & Sgarbossa, F. (2022). A novel decision support system for managing predictive maintenance strategies based on machine learning approaches. *Safety Science*, *146*. Scopus. https://doi.org/10.1016/j.ssci.2021.105529

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Asanuma, B. (1989). Manufacturer-supplier relationships in Japan and the concept of relation-specific skill. *Journal of the Japanese and International Economies*, *3*(1), 1–30. https://doi.org/10.1016/0889-1583(89)90029-4

Asiaei, K., & Bontis, N. (2019). Translating knowledge management into performance: The role of performance measurement systems. *Management Research Review*, *43*(1), 113–132. https://doi.org/10.1108/MRR-10-2018-0395

Asrar-ul-Haq, M., & Anwar, S. (2016). A systematic review of knowledge management and knowledge sharing: Trends, issues, and challenges. In *COGENT BUSINESS*

& MANAGEMENT (Vol. 3). TAYLOR & FRANCIS AS. https://doi.org/10.1080/23311975.2015.1127744

Assaad, W., & Gómez, J. (2011). Social Network in Marketing (Social Media Marketing) Opportunities and Risks. *Managerial Marketing EJournal*. https://www.semanticscholar.org/paper/Social-Network-in-Marketing-(Social-Media-and-Risks-Assaad-G%C3%B3mez/91494988f7eeef2f56ecb0dd0a69f98629cbbf25

Atrash, A., Abel, M.-H., Moulin, C., Darène, N., Huet, F., & Bruaux, S. (2015). Note-taking as a main feature in a social networking platform for small and medium sized enterprises. *Computers in Human Behavior*, *51*, 705–714. https://doi.org/10.1016/j.chb.2014.12.010

Ayatollahi, H., & Zeraatkar, K. (2020). Factors influencing the success of knowledge management process in health care organisations: A literature review. In *HEALTH INFORMATION AND LIBRARIES JOURNAL* (Vol. 37, Issue 2, pp. 98–117). WILEY. https://doi.org/10.1111/hir.12285

Bahar, N., Wahab, S. N., & Rahman, M. (2020). Impact of knowledge management capability on supply chain management and organizational practices in logistics industry. *VINE Journal of Information and Knowledge Management Systems*, *51*(5), 677–692. https://doi.org/10.1108/VJIKMS-02-2020-0022

Bai, C., Dallasega, P., Orzes, G., & Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. *International Journal of Production Economics*, *229*, 107776. https://doi.org/10.1016/j.ijpe.2020.107776

Bamel, N., Pereira, V., Bamel, U., & Cappiello, G. (2021). Knowledge management within a strategic alliances context: Past, present and future. *Journal of*

Knowledge Management, *25*(7), 1782–1810. https://doi.org/10.1108/JKM-06-2020-0443

Barlow, A., & Bocko, A. (2020). Working outside the lines: A case for knowledge exchange in the academic library. *Journal of Electronic Resources Librarianship*, *32*(2), Article 2. https://doi.org/10.1080/1941126X.2020.1739819

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120.

Beaumont, M., Thuriaux-Alemán, B., Prasad, P., & Hatton, C. (2017). Using Agile approaches for breakthrough product innovation. *Strategy & Leadership*, *45*(6), Article 6. https://doi.org/10.1108/SL-08-2017-0076

Beck, K. (2001). Manifesto for Agile Software Development. *Manifesto for Agile Software Development*.

Bekkouche, A., Benslimane, S. M., Huchard, M., Tibermacine, C., Hadjila, F., & Merzoug, M. (2017). QoS-aware optimal and automated semantic web service composition with user's constraints. *Service Oriented Computing and Applications*, *11*(2), 183–201. https://doi.org/10.1007/s11761-017-0205-1

Belbaly Aissa, N., Gurău, C., Psychogios, A., & Somsing, A. (2022). Transactional memory systems in virtual teams: Communication antecedents and the impact of TMS components on creative processes and outcomes. *Technological Forecasting and Social Change*, *174*, 121235. https://doi.org/10.1016/j.techfore.2021.121235

Bele, N., Panigrahi, P. K., & Srivastava, S. K. (2018). Knowledge Discovery From Vernacular Expressions: An Application of Social Media and Sentiment Mining. *International Journal of Knowledge Management (IJKM)*, *14*(1), 1–18. https://doi.org/10.4018/IJKM.2018010101

Belisle, C. (2006). *Literacy and the digital knowledge revolution* (Vol. 7). Facet Publishing. https://www.researchgate.net/publication/278745156_Literacy_and_the_digital_knowledge_revolution

Benbouja, M., Touil, A., Echchatbi, A., & Charkaoui, A. (2021). Supply chain integration within mass customization: Tactical procurement, production and distribution modeling. *Journal of Industrial Engineering and Management*, *14*(2), 250–268. Scopus. https://doi.org/10.3926/jiem.3182

Benckendorff, P. (2009). Evaluating Wikis as an Assessment Tool for Developing Collaboration and Knowledge Management Skills. *Journal of Hospitality and Tourism Management*, *16*(1), Article 1. https://doi.org/10.1375/jhtm.16.1.102

Berthomieu, C., Chanel-Reynaud, C., Guighard, J. P., Hanaut, A., & Longhi, A. (1983). *Structure industrielle et sous-traitance*. Presses universitaires de France.

Bettiol, M., Capestro, M., Di Maria, E., & Micelli, S. (2022). Disentangling the link between ICT and Industry 4.0: Impacts on knowledge-related performance. *International Journal of Productivity and Performance Management*, *71*(4), Article 4. https://doi.org/10.1108/IJPPM-10-2020-0573

Bhosale, V., & Kant, R. (2016). Metadata analysis of knowledge management in supply chain. *Business Process Management Journal*, *22*, 140–172. https://doi.org/10.1108/BPMJ-02-2015-0014

Bibri, S. E. (2018). The IoT for smart sustainable cities of the future: An analytical framework for sensor-based big data applications for environmental sustainability. *Sustainable Cities and Society*, *38*, 230–253. https://doi.org/10.1016/j.scs.2017.12.034

Birou, L. M., Green, K. W., & Inman, R. A. (2019). Sustainability knowledge and training: Outcomes - ProQuest. *Journal of Manufacturing Technology Management*, *30*(2), 294–311. https://doi.org/10.1108/JMTM-05-2018-0148

Bjornson, F. O., & Dingsoyr, T. (2008). Knowledge management in software engineering: A systematic review of studied concepts, findings and research methods used. In *INFORMATION AND SOFTWARE TECHNOLOGY* (Vol. 50, Issue 11, pp. 1055–1068). ELSEVIER. https://doi.org/10.1016/j.infsof.2008.03.006

Blome, C., Schoenherr, T., & Eckstein, D. (2014). The impact of knowledge transfer and complexity on supply chain flexibility: A knowledge-based view. *International Journal of Production Economics*, *147*(PB), 307–316.

Boisot, M. H. (1998). *Knowledge Assets*. Oxford University Press. https://www.hoepli.it/libro/knowledge-assets/9780198290865.html

Bolisani, E., & Oltramari, A. (2012). Knowledge as a measurable object in business contexts: A stock-and-flow approach. *Knowledge Management Research & Practice*, *10*. https://doi.org/10.1057/kmrp.2012.13

Bolisani, E., & Scarso, E. (2014). The place of communities of practice in knowledge management studies: A critical review. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 18, Issue 2, pp. 366–381). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-07-2013-0277

Bonamigo, A., Frech, C. G., & Lopes, A. C. C. (2021). Value co-creation in the B2B context: A diagnosis of knowledge management based on multiple case studies. *Journal of Business & Industrial Marketing*, *37*(7), 1449–1462. https://doi.org/10.1108/JBIM-11-2020-0528

Bonoma, T. V. (1985). Case research in marketing: Opportunities, problems, and a process. *Journal of Marketing Research*, *22*(MAY), 199–208.

Brahimi, T., & Sarirete, A. (2015). Learning outside the classroom through MOOCs. *Computers in Human Behavior*, *51*, 604–609. https://doi.org/10.1016/j.chb.2015.03.013

Brand, M., Tiberius, V., Bican, P. M., & Brem, A. (2021). Agility as an innovation driver: Towards an agile front end of innovation framework. *Review of Managerial Science*, *15*(1), Article 1. https://doi.org/10.1007/s11846-019-00373-0

Bratianu, C., & Bejinaru, R. (2019). Knowledge dynamics: A thermodynamics approach. *Kybernetes*, *49*(1), 6–21. https://doi.org/10.1108/K-02-2019-0122

Bray, D. (2007). *Knowledge Ecosystems.* 457–462.

Bresciani, S., Ferraris, A., & Del Giudice, M. (2018). The management of organizational ambidexterity through alliances in a new context of analysis: Internet of Things (IoT) smart city projects. *Technological Forecasting and Social Change*, *136*, 331–338. Scopus. https://doi.org/10.1016/j.techfore.2017.03.002

Brown, N., & Sandholm, T. (2019). Superhuman AI for multiplayer poker. *American Association for the Advancement of Science*, *365*(6456), 885–890. https://doi.org/10.1126/science.aay2400

Browne, J., & Zhang, J. (1999). *Extended and virtual enterprises – similarities and differences*. https://doi.org/10.1108/14654659910266691

Bruno, G., Esposito, E., Genovese, A., & Passaro, R. (2012). AHP-based approaches for supplier evaluation: Problems and perspectives. *Journal of Purchasing and Supply Management*, *18*(3), 159–172.

Buenstorf, G., & Costa, C. (2018). Drivers of spin-off performance in industry clusters: Embodied knowledge or embedded firms? *Research Policy*, *47*(3), 663–673.

Buunk, I., Smith, C. F., & Hall, H. (2019). Tacit knowledge sharing in online environments: Locating 'Ba' within a platform for public sector professionals. *Journal of Librarianship and Information Science*, *51*(4), 1134–1145. https://doi.org/10.1177/0961000618769982

Cabanelas, P., Omil, J., & Vazquez, X. (2013). A methodology for the construction of dynamic capabilities in industrial networks: The role of border agents. *Industrial Marketing Management*, *42*, 992–1003. https://doi.org/10.1016/j.indmarman.2013.03.012

Calvo-Mora, A., Navarro-García, A., Rey-Moreno, M., & Periañez-Cristobal, R. (2016). Excellence management practices, knowledge management and key business results in large organisations and SMEs: A multi-group analysis. *European Management Journal*, *34*(6), 661–673. https://doi.org/10.1016/j.emj.2016.06.005

Campanelli, A. S., & Parreiras, F. S. (2015). Agile methods tailoring—A systematic literature review. *Journal of Systems and Software*, *110*, 85–100. https://doi.org/10.1016/j.jss.2015.08.035

Capaldo, G., & Volpe, A. (2021). *Project Management. Principi e metodi*. McGraw-Hill Education. https://www.ibs.it/project-management-principi-metodi-libro-guido-capaldo-antonello-volpe/e/9788838697388

Caputo, F., Magni, D., Papa, A., & Corsi, C. (2021). Knowledge hiding in socioeconomic settings: Matching organizational and environmental antecedents. *Journal of Business Research*, *135*, 19–27. https://doi.org/10.1016/j.jbusres.2021.06.012

Cardoni, A., Zanin, F., Corazza, G., & Paradisi, A. (2020). Knowledge Management and Performance Measurement Systems for SMEs' Economic Sustainability. *Sustainability*, *12*(7), Article 7. https://doi.org/10.3390/su12072594

Cassia, A. R., Costa, I., da Silva, V. H. C., & de Oliveira Neto, G. C. (2020). Systematic literature review for the development of a conceptual model on the relationship between knowledge sharing, information technology infrastructure and innovative capability. In *TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT* (Vol. 32, Issue 7, pp. 801–821). ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD. https://doi.org/10.1080/09537325.2020.1714026

Castagna, F., Centobelli, P., Cerchione, R., Esposito, E., Oropallo, E., & Passaro, R. (2020). Customer Knowledge Management in SMEs Facing Digital Transformation. *Sustainability*, *12*, 3899. https://doi.org/10.3390/su12093899

Cegarra Navarro, J. G., Dewhurst, F. W., & Eldridge, S. (2010). Linking chief knowledge officers with customer capital through knowledge management practices in the Spanish construction industry. *The International Journal of Human Resource Management*, *21*(3). https://www-tandfonline-com.ezproxy.unibg.it/doi/abs/10.1080/09585190903546946

Cegielski, C. G., Allison Jones-Farmer, L., Wu, Y., & Hazen, B. T. (2012). Adoption of cloud computing technologies in supply chains: An organizational information processing theory approach. *The International Journal of Logistics Management*, *23*(2), 184–211. https://doi.org/10.1108/09574091211265350

Centobelli, P., Cerchione, R., & Esposito, E. (2017). Efficiency and effectiveness of knowledge management systems in SMEs. *Production Planning & Control*, *30*(9), 779–791.

Centobelli, P., Cerchione, R., Esposito, E., & Oropallo, E. (2021). Surfing blockchain wave, or drowning? Shaping the future of distributed ledgers and decentralized technologies. *Technological Forecasting and Social Change*, *165*, 120463. https://doi.org/10.1016/j.techfore.2020.120463

Cerchione, R., Centobelli, P., Oropallo, E., Magni, D., & Bonin, E. (2023). *Knowing what you don't know: A tertiary study on knowledge management*. https://doi.org/10.1108/JKM-07-2022-0589

Cerchione, R., Centobelli, P., Zerbino, P., & Anand, A. (2020). Back to the future of Knowledge Management Systems off the beaten paths. In *MANAGEMENT DECISION* (Vol. 58, Issues 9, SI, pp. 1953–1984). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/MD-11-2019-1601

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., & Spadaro, M. R. (2015). The Spread of Knowledge Management in SMEs: A Scenario in Evolution. *Sustainability*, *7*(8), Article 8. https://doi.org/10.3390/su70810210

Cerchione, R., Esposito, E., & Spadaro, M. R. (2016). A literature review on knowledge management in SMEs. In *KNOWLEDGE MANAGEMENT RESEARCH & PRACTICE* (Vol. 14, Issue 2, pp. 169–177). TAYLOR & FRANCIS LTD. https://doi.org/10.1057/kmrp.2015.12

Cerezo-Narváez, A., Pastor-Fernández, A., Otero-Mateo, M., Ballesteros-Pérez, P., & Rodríguez-Pecci, F. (2021a). Knowledge as an Organizational Asset for Managing

Complex Projects: The Case of Naval Platforms. *Sustainability*, *13*(2), Article 2. https://doi.org/10.3390/su13020885

Cerezo-Narváez, A., Pastor-Fernández, A., Otero-Mateo, M., Ballesteros-Pérez, P., & Rodríguez-Pecci, F. (2021b). Knowledge as an Organizational Asset for Managing Complex Projects: The Case of Naval Platforms. *Sustainability*, *13*(2), 885. https://doi.org/10.3390/su13020885

Chaillou, B. (1977). Définition et typologie de la sous-traitance. *Revue économique*, *28*(2), 262–285. https://doi.org/10.2307/3501059

Chan, F. K. Y., & Thong, J. Y. L. (2009). Acceptance of agile methodologies: A critical review and conceptual framework. *Decision Support Systems*, *46*(4), Article 4. https://doi.org/10.1016/j.dss.2008.11.009

Chaudhuri, R., Chavan, G., Vadalkar, S., Vrontis, D., & Pereira, V. (2021). Two-decade bibliometric overview of publications in the Journal of Knowledge Management. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 25, Issue 6, pp. 1550–1574). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-07-2020-0571

Chen, M., & Chen, A. (2006). Knowledge management performance evaluation: A decade review from 1995 to 2004. In *JOURNAL OF INFORMATION SCIENCE* (Vol. 32, Issue 1, pp. 17–38). SAGE PUBLICATIONS LTD. https://doi.org/10.1177/0165551506059220

Chennamaneni, A., & Teng, J. (2011). An Integrated Framework for Effective Tacit Knowledge Transfer. In *17th Americas Conference on Information Systems 2011, AMCIS 2011* (Vol. 3).

Ching, N. T., Ghobakhloo, M., Iranmanesh, M., Maroufkhani, P., & Asadi, S. (2022). Industry 4.0 applications for sustainable manufacturing: A systematic literature review and a roadmap to sustainable development. *Journal of Cleaner Production*, *334*, 130133. https://doi.org/10.1016/j.jclepro.2021.130133

Chirumalla, K. (2021). Building digitally-enabled process innovation in the process industries: A dynamic capabilities approach. *Technovation*, *105*, 102256. https://doi.org/10.1016/j.technovation.2021.102256

Choy Chong, S., Salleh, K., Noh Syed Ahmad, S., & Syed Omar Sharifuddin, S. (2011). KM implementation in a public sector accounting organization: An empirical investigation. *Journal of Knowledge Management*, *15*(3), 497–512. https://doi.org/10.1108/13673271111137457

Ciampi, F., Marzi, G., Demi, S., & Faraoni, M. (2020). The big data-business strategy interconnection: A grand challenge for knowledge management. A review and future perspectives. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 24, Issue 5, pp. 1157–1176). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-02-2020-0156

Clark, C. J., & Mason, E. B. (2008). A Wiki Way of Working. *Internet Reference Services Quarterly*, *13*(1), Article 1. https://doi.org/10.1300/J136v13n01_07

Clark, S. M., Gioia, D. A., Ketchen Jr., D. J., & Thomas, J. B. (2010). Transitional identity as a facilitator of organizational identity change during a merger. *Administrative Science Quarterly*, *55*(3), 397–438. https://doi.org/10.2189/asqu.2010.55.3.397

Clemons, R., & Slotnick, S. A. (2016). The effect of supply-chain disruption, quality and knowledge transfer on firm strategy. *International Journal of Production Economics*, *178*(C), 169–186.

Cobo, M., Chiclana, F., Collop, A., De Oña, J., & Herrera-Viedma, E. (2014). A Bibliometric Analysis of the Intelligent Transportation Systems Research Based on Science Mapping. *Intelligent Transportation Systems, IEEE Transactions On*, *15*, 901–908. https://doi.org/10.1109/TITS.2013.2284756

Cobo, M., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). Science Mapping Software Tools: Review, Analysis, and Cooperative Study Among Tools. *Journal of the American Society for Information Science and Technology*, *62*, 1382–1402. https://doi.org/10.1002/asi.21525

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, *35*(1), 128–152. https://doi.org/10.2307/2393553

Colombo, M. G., & Mariotti, S. (1998). Organizing vertical markets: The Italtel case. *European Journal of Purchasing and Supply Management*, *4*, 7–19.

Conboy, K., & Fitzgerald, B. (2004). Toward a conceptual framework of agile methods: A study of agility in different disciplines. *WISER 2004 - ACM Workshop on Interdisciplinary Software Engineering Research*, 37–44. https://www.scopus.com/inward/record.uri?eid=2-s2.0-27644521512&partnerID=40&md5=6200b013ecb0129bc0080110a20fae62

Cornélio, N. A. G., Abreu, A. F. de, & Costa, E. de O. (2010). Espaço interativo: Modelo de relação universidade-empresa baseada em comunidades de prática. *Ciência da Informação*, *39*(1), Article 1. https://doi.org/10.1590/S0100-19652010000100001

Cram, W. A., & Newell, S. (2016). Mindful revolution or mindless trend? Examining agile development as a management fashion. *European Journal of Information Systems*, *25*(2), 154–169. https://doi.org/10.1057/ejis.2015.13

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Sage.

Cripps, H., Singh, A., Mejtoft, T., & Salo, J. (2020). The use of Twitter for innovation in business markets. *Marketing Intelligence & Planning*, *38*(5), 587–601. https://doi.org/10.1108/MIP-06-2019-0349

Crupi, A., Del Sarto, N., Di Minin, A., Gregori, G. L., Lepore, D., Marinelli, L., & Spigarelli, F. (2020). The digital transformation of SMEs – a new knowledge broker called the digital innovation hub. *Journal of Knowledge Management*, *24*(6), 1263–1288. https://doi.org/10.1108/JKM-11-2019-0623

da Silva Alfenas, R. A., dos Santos, C. S., da Silva Dias, D. C., Brito de Araujo, V. G., & Montes Rey Silva, D. V. F. (2021). Knowledge management in Brazilian public organizations: A literature review of the period 2008—2017. In *REVISTA DO SERVICO PUBLICO* (Vol. 72, Issue 2, pp. 452–478). ESCOLA NACL ADM PUBLICA-ENAP. https://doi.org/10.21874/rsp.v72.i1.3913

Dalkir, K. (2013). *Knowledge Management in Theory and Practice* (0 ed.). Routledge. https://doi.org/10.4324/9780080547367

D'Andrea, F. A. M. C., Rigon, F., Almeida, A. C. L. de, Filomena, B. da S., & Slongo, L. A. (2019). Co-creation: A B2C and B2B comparative analysis. *Marketing Intelligence & Planning*, *37*(6), 674–688. https://doi.org/10.1108/MIP-08-2018-0306

Dao, V., Langella, I., & Carbo, J. (2011). From Green to Sustainability: Information Technology and an Integrated Sustainability Framework. *J. Strategic Inf. Sys.*, *20*, 63–79. https://doi.org/10.1016/j.jsis.2011.01.002

David, R. J., & Han, S.-K. (2004). A systematic assessment of the empirical support for transaction cost economics. *Strategic Management Journal*, *25*(1), 39–58. https://doi.org/10.1002/smj.359

Davis, J., Edgar, T., Graybill, R., Korambath, P., Schott, B., Swink, D., Wang, J., & Wetzel, J. (2015). Smart Manufacturing. *Annual Review of Chemical and Biomolecular Engineering*, *6*(1), Article 1. https://doi.org/10.1146/annurev-chembioeng-061114-123255

De Bellis, N. (2009). *Bibliometrics and Citation Analysis: From the Science Citation Index to Cybermetrics,* (Lanham, Vol. 5). Plymouth.

de Bem Machado, A., Secinaro, S., Calandra, D., & Lanzalonga, F. (2022). Knowledge management and digital transformation for Industry 4.0: A structured literature review. *Knowledge Management Research & Practice*, *20*(2), 320–338. https://doi.org/10.1080/14778238.2021.2015261

de Carvalho, G. D. G., de Carvalho, H. G., Cardoso, H. H. R., & Gonçalves, A. D. (2018). Assessing a Micro and Small Businesses Innovation Support Programme in Brazil: The Local Innovation Agents Programme. *Journal of International Development*, *30*(6), 1064–1068. https://doi.org/10.1002/jid.3387

de Castro, R. O., Sanin, C., Levula, A., & Szczerbicki, E. (2021). The Development of a Conceptual Framework for Knowledge Sharing in Agile IT Projects. *Cybernetics and Systems*, 1–12. https://doi.org/10.1080/01969722.2021.2018541

De Cesare, S., Lycett, M., MacRedie, R. D., Patel, C., & Paul, R. (2010). Examining perceptions of agility in software development practice. *Communications of the ACM*, *53*(6), 126–130. https://doi.org/10.1145/1743546.1743580

de Laat, M., Lally, V., Lipponen, L., & Simons, R.-J. (2007). Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for Social Network Analysis. *International Journal of Computer-Supported Collaborative Learning*, *2*(1), 87–103. https://doi.org/10.1007/s11412-007-9006-4

De Toni, A., & Nassimbeni, G. (1995). Supply networks: Genesis, stability and logistics implications. A comparative analysis of two districts. *Omega*, *23*(4), 403–418.

Del Giudice, M., Carayannis, E. G., & Maggioni, V. (2017). Global knowledge intensive enterprises and international technology transfer: Emerging perspectives from a quadruple helix environment. *Journal of Technology Transfer*, *42*(2), 229–235. Scopus. https://doi.org/10.1007/s10961-016-9496-1

Del Giudice, M., & Maggioni, V. (2014). Managerial practices and operative directions of knowledge management within inter-firm networks: A global view. *Journal of Knowledge Management*, *18*(5), 841–846. Scopus. https://doi.org/10.1108/JKM-06-2014-0264

Del Giudice, M., Scuotto, V., Papa, A., Tarba, S. Y., Bresciani, S., & Warkentin, M. (2021). A Self-Tuning Model for Smart Manufacturing SMEs: Effects on Digital Innovation. *Journal of Product Innovation Management*, *38*(1), 68–89. Scopus. https://doi.org/10.1111/jpim.12560

del Rosario Perez-Salazar, M., Aguilar Lasserre, A. A., Gaston Cedillo-Campos, M., & Hernandez Gonzalez, J. C. (2017). The Role of Knowledge Management in Supply Chain Management: A Literature Review. In *JOURNAL OF INDUSTRIAL ENGINEERING AND MANAGEMENT-JIEM* (Vol. 10, Issues 4, SI, pp. 711–788). OMNIASCIENCE. https://doi.org/10.3926/jiem.2144

del Rosario Perez-Salazar, M., Aguilar-Lasserre, A. A., Gaston Cedillo-Campos, M., Juarez-Martinez, U., & Posada-Gomez, R. (2019). Processes and measurement of knowledge management in supply chains: An integrative systematic literature review. In *INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH* (Vol. 57, Issue 7, pp. 2136–2159). TAYLOR & FRANCIS LTD. https://doi.org/10.1080/00207543.2018.1521530

Delen, D., Kuzey, C., & Uyar, A. (2013). Measuring firm performance using financial ratios: A decision tree approach. *Expert Systems with Applications*, *40*(10), 3970–3983. https://doi.org/10.1016/j.eswa.2013.01.012

Desouza, K., & Awazu, Y. (2006). Knowledge management at SMEs. *J. Knowledge Management*, *10*, 32–43. https://doi.org/10.1108/13673270610650085

Dezi, L., Ferraris, A., Papa, A., & Vrontis, D. (2021). The Role of External Embeddedness and Knowledge Management as Antecedents of Ambidexterity and Performances in Italian SMEs. *IEEE Transactions on Engineering Management*, *68*(2), 360–369. Scopus. https://doi.org/10.1109/TEM.2019.2916378

Di Vaio, A., Palladino, R., Pezzi, A., & Kalisz, D. E. (2021). The role of digital innovation in knowledge management systems: A systematic literature review. *Journal of Business Research*, *123*, 220–231. https://doi.org/10.1016/j.jbusres.2020.09.042

Ding, H., & Peters, L. (2000). Inter-firm knowledge management practices for technology and new product development in discontinuous innovation. *Int. J. Technol. Manag.* https://doi.org/10.1504/IJTM.2000.002883

Ding, Y. (2011). Scientific collaboration and endorsement: Network analysis of coauthorship and citation networks. *Journal of Informetrics*, *5*(1), 187–203. https://doi.org/10.1016/j.joi.2010.10.008

Dingsøyr, T., & Hanssen, G. K. (2003). Extending Agile Methods: Postmortem Reviews as Extended Feedback. In S. Henninger & F. Maurer (Eds.), *Advances in Learning Software Organizations* (Vol. 2640, pp. 4–12). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-40052-3_2

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*. https://doi.org/10.1016/j.jbusres.2021.04.070

Dragicevic, P., Jansen, Y., Sarma, A., Kay, M., & Chevalier, F. (2019). Increasing the Transparency of Research Papers with Explorable Multiverse Analyses. In *CHI '19: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (p. 15). https://doi.org/10.1145/3290605.3300295

Drury, M., Conboy, K., & Power, K. (2012). Obstacles to decision making in Agile software development teams. *Journal of Systems and Software*, *85*(6), 1239–1254. https://doi.org/10.1016/j.jss.2012.01.058

Durach, C. F., Wiengarten, F., & Choi, T. Y. (2020). Supplier–supplier coopetition and supply chain disruption: First-tier supplier resilience in the tetradic context. *International Journal of Operations and Production Management*, *40*(7–8), 1041–1065. https://doi.org/10.1108/IJOPM-03-2019-0224

Durst, S. (2019). How far have we come with the study of knowledge risks? In *VINE JOURNAL OF INFORMATION AND KNOWLEDGE MANAGEMENT SYSTEMS* (Vol. 49, Issue 1, pp. 21–34). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/VJIKMS-10-2018-0087

Durst, S., & Edvardsson, I. R. (2012). Knowledge management in SMEs: A literature review. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 16, Issue 6, pp.

879–903). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/13673271211276173

Eaton, P. W., & Pasquini, L. A. (2020). Networked practices in higher education: A netnography of the #AcAdv chat community. *The Internet and Higher Education*, *45*, 100723. https://doi.org/10.1016/j.iheduc.2019.100723

Edvardsson, I. R., & Durst, S. (2014). Outsourcing of knowledge processes: A literature review. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 18, Issue 4, pp. 795–811). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-01-2014-0033

Edvinsson, L. (1997). Developing intellectual capital at Skandia. *Long Range Planning*, *30*(3), 366–373. https://doi.org/10.1016/S0024-6301(97)90248-X

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, *14*(4), 532–550. https://doi.org/10.2307/258557

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/AMJ.2007.24160888

Escribano, A., Fosfuri, A., & Tribó, J. A. (2009). Managing external knowledge flows: The moderating role of absorptive capacity. *Research Policy*, *38*(1), 96–105. https://doi.org/10.1016/j.respol.2008.10.022

Esposito, E., & Passaro, R. (2009). The evolution of supply chain relationships: An interpretative framework based on the Italian inter-industry experience. *Journal of Purchasing and Supply Management*, *15*, 114–126. https://doi.org/10.1016/j.pursup.2009.03.002

Esposito, E., & Raffa, M. (1994). The evolution of Italian subcontracting firms: Empirical evidence. *European Journal of Purchasing & Supply Management*, *1*(2), 67–76. https://doi.org/10.1016/0969-7012(94)90017-5

Fakhar Manesh, M., Pellegrini, M. M., Marzi, G., & Dabic, M. (2021). Knowledge Management in the Fourth Industrial Revolution: Mapping the Literature and Scoping Future Avenues. *IEEE Transactions on Engineering Management*, *68*(1), Article 1. https://doi.org/10.1109/TEM.2019.2963489

Feng, Q., & Shanthikumar, J. G. (2018). How Research in Production and Operations Management May Evolve in the Era of Big Data. *Production and Operations Management*, *27*(9), 1670–1684. https://doi.org/10.1111/poms.12836

Feo, E., Spanoghe, P., Berckmoes, E., Pascal, E., Mosquera-Losada, R., Opdebeeck, A., & Burssens, S. (2022). The multi-actor approach in thematic networks for agriculture and forestry innovation. *Agricultural and Food Economics*, *10*(1), Article 1. https://doi.org/10.1186/s40100-021-00209-0

Floyde, A., Lawson, G., Shalloe, S., Eastgate, R., & D'Cruz, M. (2013). The design and implementation of knowledge management systems and e-learning for improved occupational health and safety in small to medium sized enterprises. In *SAFETY SCIENCE* (Vol. 60, pp. 69–76). ELSEVIER. https://doi.org/10.1016/j.ssci.2013.06.012

Foster-McGregor, N., Nomaler, Ö., & Verspagen, B. (2021). Job Automation Risk, Economic Structure and Trade: A European Perspective. *Research Policy*, *50*(7), 104269. https://doi.org/10.1016/j.respol.2021.104269

Fragapane, G., Ivanov, D., Peron, M., Sgarbossa, F., & Strandhagen, J. O. (2022). Increasing flexibility and productivity in Industry 4.0 production networks with

autonomous mobile robots and smart intralogistics. *Annals of Operations Research*, *308*(1–2), 125–143. Scopus. https://doi.org/10.1007/s10479-020-03526-7

Frederico, G. F., Garza-Reyes, J. A., Kumar, A., & Kumar, V. (2020). Performance measurement for supply chains in the Industry 4.0 era: A balanced scorecard approach. *International Journal of Productivity and Performance Management*, *70*(4), 789–807. https://doi.org/10.1108/IJPPM-08-2019-0400

Galli, A., Gravina, M., Moscato, V., Picariello, A., Sansone, C., & Sperlí, G. (2019). A Business Reputation Methodology Using Social Network Analysis. In C. Esposito, J. Hong, & K.-K. R. Choo (Eds.), *Pervasive Systems, Algorithms and Networks* (pp. 96–106). Springer International Publishing. https://doi.org/10.1007/978-3-030-30143-9_8

Gansterer, M., Födermayr, P., & Hartl, R. F. (2021). The capacitated multi-level lot-sizing problem with distributed agents. *International Journal of Production Economics*, *235*. Scopus. https://doi.org/10.1016/j.ijpe.2021.108090

Gelderman, C. J., & Semeijn, J. (2006). Managing the global supply base through purchasing portfolio management. *Journal of Purchasing and Supply Management*, *12*(4), 209–217. https://doi.org/10.1016/j.pursup.2006.10.002

Genovese, A., Acquaye, A. A., Figueroa, A., & Koh, S. C. L. (2017). Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications. *Omega*, *66*(PB), 344–357.

Georgiev, G. V., & Georgiev, D. D. (2018). Enhancing user creativity: Semantic measures for idea generation. *Knowledge-Based Systems*, *151*, 1–15.

Ghezzi, A., & Cavallo, A. (2020). Agile Business Model Innovation in Digital Entrepreneurship: Lean Startup Approaches. *Journal of Business Research*, *110*, 519–537. https://doi.org/10.1016/j.jbusres.2018.06.013

Gil, D., Ferrández, A., Mora-Mora, H., & Peral, J. (2016). Internet of Things: A Review of Surveys Based on Context Aware Intelligent Services. *Sensors*, *16*(7), Article 7. https://doi.org/10.3390/s16071069

Glänzel, W., & Thijs, B. (2011). *Research in Emerging Fields: Who Takes the Lead?* (SSRN Scholarly Paper ID 2105514). Social Science Research Network. https://doi.org/10.2139/ssrn.2105514

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers*. Longman Publishing Group.

Grass, A., Backmann, J., & Hoegl, M. (2020). From Empowerment Dynamics to Team Adaptability: Exploring and Conceptualizing the Continuous Agile Team Innovation Process. *Journal of Product Innovation Management*, *37*(4), Article 4. https://doi.org/10.1111/jpim.12525

Grover, V., Chiang, R., Liang, T.-P., & Zhang, D. (2018). Creating Strategic Business Value from Big Data Analytics: A Research Framework. *Journal of Management Information Systems*, *35*, 388–423. https://doi.org/10.1080/07421222.2018.1451951

Grum, M., & Gronau, N. (2017). *Integration of Augmented Reality Technologies in Process Modeling—The Augmentation of Real World Scenarios With the KMDL*. 206–215. https://www.scitepress.org/Link.aspx?doi=10.5220/0006529102060215

Gunasekaran, A., & Ngai, E. W. T. (2007). Knowledge management in 21st century manufacturing. In *INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH* (Vol. 45, Issue 11, pp. 2391–2418). TAYLOR & FRANCIS LTD. https://doi.org/10.1080/00207540601020429

Guo, J., Zhou, S., Chen, J., & Chen, Q. (2021). How information technology capability and knowledge integration capability interact to affect business model design:A polynomial regression with response surface analysis. *Technological Forecasting and Social Change*, *170*, 120935. https://doi.org/10.1016/j.techfore.2021.120935

Handfield, R. B., & Melnyk, S. A. (1998). The scientific theory-building process: A primer using the case of TQM. *Journal of Operations Management*, *16*(4), 321–339. https://doi.org/10.1016/s0272-6963(98)00017-5

Hannola, L., Richter, A., Richter, S., & Stocker, A. (2018). Empowering production workers with digitally facilitated knowledge processes – a conceptual framework. *International Journal of Production Research*, *56*(14), Article 14. https://doi.org/10.1080/00207543.2018.1445877

He, Q. (1999). Knowledge discovery through co-word analysis. *Librar Trends*, *49*(1), 133–159.

Hendriks, P., & Sousa, C. (2013). Practices of management knowing in university research management. *Journal of Organizational Change Management*, *26*. https://doi.org/10.1108/09534811311328605

Heredia, A., Garcia-Guzman, J., Amescua-Seco, A., & Serrano, A. (2014). Study of Factors Influencing the Adoption of Agile Processes When Using Wikis. *International Journal of Software Engineering and Knowledge Engineering*, *24*(06), Article 06. https://doi.org/10.1142/S0218194014400014

Herschel, R., & Jones, N. (2005). Knowledge management and business intelligence: The importance of integration. *J. Knowledge Management*, *9*, 45–55. https://doi.org/10.1108/13673270510610323

Hess, T., Matt, C., Benlian, A., & Wiesböck, F. (2016). Options for Formulating a Digital Transformation Strategy. *MIS Quarterly Executive*, *15*, 123–139.

Hidalgo, E. S. (2019). Adapting the scrum framework for agile project management in science: Case study of a distributed research initiative. *Heliyon*, *5*(3), Article 3. https://doi.org/10.1016/j.heliyon.2019.e01447

Hildrum, J. M. (2009). Sharing Tacit Knowledge Online: A Case Study of e-Learning in Cisco's Network of System Integrator Partner Firms. *Industry and Innovation*, *16*(2), 197–218.

Hines, P. (1994). *Creating world class suppliers: Unlocking mutual competitive advantage*. Pitman.

Holbeche, L. S. (2018). Organisational effectiveness and agility. *Journal of Organizational Effectiveness: People and Performance*, *5*(4), 302–313. https://doi.org/10.1108/JOEPP-07-2018-0044

Holden, R. J., Boustani, M. A., & Azar, J. (2021). Agile Innovation to transform healthcare: Innovating in complex adaptive systems is an everyday process, not a light bulb event. *BMJ Innovations*, *7*(2), Article 2. https://doi.org/10.1136/bmjinnov-2020-000574

Holsapple, C. (2005). The inseparability of modern knowledge management and computer-based technology. *J. Knowledge Management*, *9*, 42–52. https://doi.org/10.1108/13673270510582956

Holz, H., & Maurer, F. (2003). Knowledge Management Support for Distributed Agile Software Processes. In S. Henninger & F. Maurer (Eds.), *Advances in Learning Software Organizations* (Vol. 2640, pp. 60–80). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-40052-3_7

Holz, H., & Schafer, J. (2003). Collaborative, task-specific information delivery for agile processes. *WET ICE 2003. Proceedings. Twelfth IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises, 2003.*, 320–325. https://doi.org/10.1109/ENABL.2003.1231430

Hsu, T., Ke, H., & Yang, W. (2006). Unified knowledge-based content management for digital archives in museums. *The Electronic Library*, *24*(1), Article 1. https://doi.org/10.1108/02640470610649236

Iddy, J. J., & Alon, I. (2019). Knowledge management in franchising: A research agenda. *763-785*. https://doi.org/10.1108/JKM-07-2018-0441

Ilvonen, I., Thalmann, S., Manhart, M., & Sillaber, C. (2018). Reconciling digital transformation and knowledge protection: A research agenda. In *KNOWLEDGE MANAGEMENT RESEARCH & PRACTICE* (Vol. 16, Issue 2, pp. 235–244). TAYLOR & FRANCIS LTD. https://doi.org/10.1080/14778238.2018.1445427

Inayat, I., & Salim, S. S. (2015). A framework to study requirements-driven collaboration among agile teams: Findings from two case studies. *Computers in Human Behavior*, *51*, 1367–1379. https://doi.org/10.1016/j.chb.2014.10.040

Inkinen, H. (2016). Review of empirical research on knowledge management practices and firm performance. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 20, Issue 2, pp. 230–257). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-09-2015-0336

Intezari, A., Pauleen, D. J., & Taskin, N. (2021). Towards a foundational KM theory: A culture-based perspective. *Journal of Knowledge Management*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/JKM-03-2021-0249

Janes, A., & Succi, G. (2012). The dark side of agile software development. *SPLASH 2012: Onward! 2012 - Proceedings of the ACM International Symposium on New Ideas, New Paradigms, and Reflections on Programming and Software*, 215–227. https://doi.org/10.1145/2384592.2384612

Järvi, K., Almpanopoulou, A., & Ritala, P. (2018). Organization of knowledge ecosystems: Prefigurative and partial forms. *Research Policy*, *47*(8), 1523–1537. https://doi.org/10.1016/j.respol.2018.05.007

Javi, K., Kurtzman, G. M., Nadi, M., & Javi, H. (2018). Utilization of concentrated growth factor as a sole sinus augmentation material. *International Journal of Growth Factors and Stem Cells in Dentistry*, *1*(3), 95.

Jeyanthi, P. M., Mansurali, A., Harish, V., & Krishnaveni, V. D. (2020). Conceptual Framework of Customer Value Management (CVM) in Indian Banking Sector. *Webology*, *17*(2), 971–980. https://doi.org/10.14704/WEB/V17I2/WEB17081

Johannessen, J.-A., Olaisen, J., & Olsen, B. (2001). Mismanagement of tacit knowledge: The importance of tacit knowledge, the danger of information technology, and what to do about it. *International Journal of Information Management*, *21*(1), 3–20. https://doi.org/10.1016/S0268-4012(00)00047-5

Johnsen, T. E., Miemczyk, J., & Howard, M. (2017). A systematic literature review of sustainable purchasing and supply research: Theoretical perspectives and opportunities for IMP-based research. *Industrial Marketing Management*, *61*, 130–143. https://doi.org/10.1016/j.indmarman.2016.03.003

Johnston, A. (2014). Rigour in research: Theory in the research approach. *European Business Review*, *26*(3), Article 3. https://doi.org/10.1108/EBR-09-2013-0115

Jones, S.-L., Procter, R., & Younie, S. (2015). Participatory knowledge mobilisation: An emerging model for international translational research in education. *Journal of Education for Teaching*, *41*(5), 555–573. https://doi.org/10.1080/02607476.2015.1105540

Jüttner, U., & Maklan, S. (2011). Supply chain resilience in the global financial crisis: An empirical study. *Supply Chain Management: An International Journal*, *16*, 246–259. https://doi.org/10.1108/13598541111139062

Jyothi, V. E., & Rao, K. N. (2012). Effective implementation of agile practices—Incoordination with lean Kanban. *International Journal of Computational Science and Engineering*, *4*(1), 87.

Kaklauskas, A., & Kanapeckiene, L. (2005). Knowledge Management and "BRITA in PuBs" Project. *Ukio Technologinis Ir Ekonominis Vystymas*, *11*(2), 78–86. https://doi.org/10.1080/13928619.2005.9637685

Kashav, S., Centobelli, P., Cerchione, R., & Merigo, J. M. (2021). Mapping knowledge management research: A bibliometric overview. *Technological and Economic Development of Economy*, *28*, 1–29. https://doi.org/10.3846/tede.2021.14088

Kevin Sungkur, R., & Ramasawmy, M. (2014). Knowledge4Scrum, a novel knowledge management tool for agile distributed teams. *VINE*, *44*(3), Article 3. https://doi.org/10.1108/VINE-12-2013-0068

Khalil, C., & Khalil, S. (2020). Exploring knowledge management in agile software development organizations. *International Entrepreneurship and Management Journal*, *16*(2), Article 2. https://doi.org/10.1007/s11365-019-00582-9

Khan, O., & Jones, N. (2011). Harnessing tacit knowledge for innovation creation in multinational enterprises: An internal social network approach. *J. for International Business and Entrepreneurship Development*, *5*, 232–248. https://doi.org/10.1504/JIBED.2011.038031

Khan, Z., & Vorley, T. (2017). Big data text analytics: An enabler of knowledge management. *Journal of Knowledge Management*, *21*(1), 18–34. https://doi.org/10.1108/JKM-06-2015-0238

Klein, B., Crawford, R., & Alchian, A. (1978). Vertical integration, appropriable rents and the competitive contracting process. *The Journal of Law and Economics*, *21*, 297–326.

Kroenke. (2018). *Using MIS* (5th ed.). Prentice Hall.

Kuah, C. T., & Wong, K. Y. (2011). Knowledge management performance measurement: A review. In *AFRICAN JOURNAL OF BUSINESS MANAGEMENT* (Vol. 5, Issue 15, pp. 6021–6027). ACADEMIC JOURNALS.

Kumar, M., Paul, J., Misra, M., & Romanello, R. (2021). The creation and development of learning organizations: A review. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 25, Issue 10, pp. 2540–2566). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-10-2020-0795

Kumari, A., Tanwar, S., Tyagi, S., & Kumar, N. (2018). Fog computing for Healthcare 4.0 environment: Opportunities and challenges. *Comput. Electr. Eng.* https://doi.org/10.1016/j.compeleceng.2018.08.015

Laanti, M., Salo, O., & Abrahamsson, P. (2011). Agile methods rapidly replacing traditional methods at Nokia: A survey of opinions on agile transformation.

Information and Software Technology, *53*(3), 276–290. https://doi.org/10.1016/j.infsof.2010.11.010

Lamming, R. (1993). *Beyond Partnership: Strategies for Innovation and Lean Supply*. Prentice Hall.

Latilla, V. M., Frattini, F., Petruzzelli, A. M., & Berner, M. (2018). Knowledge management, knowledge transfer and organizational performance in the arts and crafts industry: A literature review. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 22, Issue 6, pp. 1310–1331). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-08-2017-0367

Lee, C. S., & Wong, K. Y. (2015). Development and validation of knowledge management performance measurement constructs for small and medium enterprises. *Journal of Knowledge Management*, *19*(4), 711–734. https://doi.org/10.1108/JKM-10-2014-0398

Lehrer, C., Wieneke, A., Brocke, J. vom, Jung, R., & Seidel, S. (2018). How Big Data Analytics Enables Service Innovation: Materiality, Affordance, and the Individualization of Service. *Journal of Management Information Systems*, *35*, 424–460. https://doi.org/10.1080/07421222.2018.1451953

Levy, M., & Grewal, D. (2000). Supply chain management in a networked economy. *Journal of Retailing*, *76*(4), 415–429.

Li, X., Lyu, M., Wang, Z., Chen, C.-H., & Zheng, P. (2021). Exploiting knowledge graphs in industrial products and services: A survey of key aspects, challenges, and future perspectives. In *COMPUTERS IN INDUSTRY* (Vol. 129). ELSEVIER. https://doi.org/10.1016/j.compind.2021.103449

Li, Z., Kang, J., Yu, R., Ye, D., Deng, Q., & Zhang, Y. (2018). Consortium blockchain for secure energy trading in industrial internet of things. *IEEE Transactions on Industrial Informatics*, *14*(8), 3690–3700. https://doi.org/10.1109/TII.2017.2786307

Li, Z., Wang, W., Liu, G., Liu, L., He, J., & Huang, G. Q. (2018). Toward open manufacturing a cross-enterprises knowledge and services exchange framework based on blockchain and edge computing. *Industrial Management and Data Systems*, *118*(1), 303–320. https://doi.org/10.1108/IMDS-04-2017-0142

Lima, M. (2020). Smarter organizations: Insights from a smart city hybrid framework. *International Entrepreneurship and Management Journal*, *16*(4), Article 4. https://doi.org/10.1007/s11365-020-00690-x

Lin, Y. C., & Ha, N.-H. (2015). The Framework for KM Implementation in Product and Service Oriented SMEs: Evidence from Field Studies in Taiwan. *Sustainability*, *7*(3), Article 3. https://doi.org/10.3390/su7032980

Liu, W., Wei, W., Si, C., Xie, D., & Chen, L. (2020). Effect of supply chain strategic collaboration announcements on shareholder value: An empirical investigation from China. *International Journal of Operations and Production Management*, *40*(4), 389–414. Scopus. https://doi.org/10.1108/IJOPM-05-2019-0368

Loureiro, S. M. C., Guerreiro, J., & Tussyadiah, I. (2021). Artificial intelligence in business: State of the art and future research agenda. *Journal of Business Research*, *129*, 911–926. https://doi.org/10.1016/j.jbusres.2020.11.001

Lu, J., Behbood, V., Hao, P., Zuo, H., Xue, S., & Zhang, G. (2015). Transfer learning using computational intelligence: A survey. *Knowledge-Based Systems*, *80*, 14–23. https://doi.org/10.1016/j.knosys.2015.01.010

Macnamara, J., & Zerfass, A. (2012). Social Media Communication in Organizations: The Challenges of Balancing Openness, Strategy, and Management. *International Journal of Strategic Communication*, *6*(4), 287–308. https://doi.org/10.1080/1553118X.2012.711402

Maghssudipour, A., Lazzeretti, L., & Capone, F. (2020). The role of multiple ties in knowledge networks: Complementarity in the Montefalco wine cluster. *Industrial Marketing Management*, *90*, 667–678. Scopus. https://doi.org/10.1016/j.indmarman.2020.03.021

Magni, D., Chierici, R., Fait, M., & Lefebvre, K. (2021). A network model approach to enhance knowledge sharing for internationalization readiness of SMEs. *International Marketing Review*, *39*(3), 626–652. https://doi.org/10.1108/IMR-03-2021-0110

Magni, D., Palladino, R., Papa, A., & Cailleba, P. (2022). Exploring the journey of Responsible Business Model Innovation in Asian companies: A review and future research agenda. *Asia Pacific Journal of Management*. https://doi.org/10.1007/s10490-022-09813-0

Magni, D., Scuotto, V., Pezzi, A., & Giudice, M. D. (2021). Employees' acceptance of wearable devices: Towards a predictive model. *Technological Forecasting and Social Change*, *172*, 121022. https://doi.org/10.1016/j.techfore.2021.121022

Mahajan, V., & Sharma, J. (2021). Self-learning and self-satisfaction: Exploring the relationship through knowledge-sharing behaviour. *International Journal of Knowledge Management*, *17*(3), 50–67. Scopus. https://doi.org/10.4018/IJKM.2021070104

Majeed, A. A., & Rupasinghe, T. D. (2017). Internet of Things (IoT) Embedded Future Supply Chains for Industry 4.0: An Assessment from an ERP-based Fashion Apparel and Footwear Industry. *International Journal of Supply Chain Management*, *6*(1), Article 1.

Maravilhas, S., & Martins, J. (2019). Strategic knowledge management in a digital environment: Tacit and explicit knowledge in Fab Labs. *Journal of Business Research*, *94*, 353–359. https://doi.org/10.1016/j.jbusres.2018.01.061

Mariano, S., & Awazu, Y. (2016). Artifacts in knowledge management research: A systematic literature review and future research directions. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 20, Issue 6, pp. 1333–1352). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-05-2016-0199

Marjanovic, O. (2021). A novel mechanism for business analytics value creation: Improvement of knowledge-intensive business processes. *Journal of Knowledge Management*, *26*(1), 17–44. https://doi.org/10.1108/JKM-09-2020-0669

Martínez-Navalón, J. G., Gelashvili, V., DeMatos, N., & Herrera-Enríquez, G. (2023). Exploring the impact of digital knowledge management on technostress and sustainability. *Journal of Knowledge Management*. Scopus. https://doi.org/10.1108/JKM-07-2022-0544

Martins, C. L., & Pato, M. V. (2019). Supply chain sustainability: A tertiary literature review. *Journal of Cleaner Production*. https://10.1016/j.jclepro.2019.03.250

Martins, F. S., Vils, L., Serra, F. A. R., da Silva Junior, W., & Napolitano, D. M. M. R. (2022). Knowledge generation and market orientation during global crises in supply chains. *European Business Review*, *34*(4), 453–470. Scopus. https://doi.org/10.1108/EBR-08-2021-0175

Martinsons, M., Davison, R., & Huang, Q. (2017). Strategic knowledge management failures in small professional service firms in China. *International Journal of Information Management*, *37*. https://doi.org/10.1016/j.ijinfomgt.2017.04.003

Massaro, M., Handley, K., Bagnoli, C., & Dumay, J. (2016). Knowledge management in small and medium enterprises: A structured literature review. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 20, Issue 2, pp. 258–291). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-08-2015-0320

Matayong, S., & Mahmood, A. K. (2013). The review of approaches to knowledge management system studies. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 17, Issue 3, pp. 472–490). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-10-2012-0316

Mazzola, E., Perrone, G., & Kamuriwo, D. S. (2016). The interaction between inter-firm and interlocking directorate networks on firm's new product development outcomes. *Journal of Business Research*, *69*(2), 672–682. https://doi.org/10.1016/j.jbusres.2015.08.033

McGrath, R. G. (2010). Business models: A discovery driven approach. *Long Range Planning*, *43*(2–3), 247–261. https://doi.org/10.1016/j.lrp.2009.07.005

Mcinerney, C. (2002). Knowledge Management and the Dynamic Nature of Knowledge. *JASIST*, *53*, 1009–1018. https://doi.org/10.1002/asi.10109

McIvor, R. (2000). A practical framework for understanding the outsourcing process. *Supply Chain Management: An International Journal*, *5*(1), 22–36. https://doi.org/10.1108/13598540010312945

Meier, M. (2011). Knowledge Management in Strategic Alliances: A Review of Empirical Evidence. *International Journal of Management Reviews*, *13*(1), 1–23.

Mennini, F. S., Magni, D., Daniele, L. M., & Favato, G. (2021). Knowledge management in turbulent times: Time-based scenario analysis of vaccinations against COVID-19. *Journal of Knowledge Management*, *26*(11), 71–88. https://doi.org/10.1108/JKM-09-2021-0710

Meredith, J. (1998). Building operations management theory through case and field research. *Journal of Operations Management*, *16*(4), 441–454. https://doi.org/10.1016/s0272-6963(98)00023-0

Mesic, Z., Molnár, A., & Cerjak, M. (2018). Assessment of traditional food supply chain performance using triadic approach: The role of relationships quality. *Supply Chain Management: An International Journal*, *23*(5), 396–411. https://doi.org/10.1108/SCM-10-2017-0336

Metaxiotis, K., Psarras, J., & Papastefanatos, S. (2002). Knowledge and information management in e-learning environments; the user agent architecture. *Information Management & Computer Security*, *10*(4), 165–170. https://doi.org/10.1108/09685220210436958

Minh Dang, L., Piran, M. J., Han, D., Min, K., & Moon, H. (2019). A Survey of Emerging Countries Economy: Sustainable Development in Social Media and Information Systems. *Electronics (Switzerland)*, *8*(7). https://doi.org/10.3390/electronics8070768

Miranda, J., Navarrete, C., Noguez, J., Molina Espinosa, J., Ramírez-Montoya, M.-S., Navarro Tuch, S., Bustamante-Bello, R., Fernández, B., & Molina, A. (2021). The core components of education 4.0 in higher education: Three case studies in engineering education. *Computers & Electrical Engineering*, *93*. https://doi.org/10.1016/j.compeleceng.2021.107278

Mora, L., Deakin, M., & Reid, A. (2019). Combining co-citation clustering and text-based analysis to reveal the main development paths of smart cities. *Technological Forecasting and Social Change*, *142*, 56–69. https://doi.org/10.1016/j.techfore.2018.07.019

Muñoz, E., Capón-García, E., Laínez, J., Espuña, A., & Puigjaner, L. (2013). Considering environmental assessment in an ontological framework for enterprise sustanability. *Journal of Cleaner Production*, *47*, 149–164. https://doi.org/10.1016/j.jclepro.2012.11.032

Najjar, M., Small, M. H., & Yasin, M. M. (2020). Social sustainability strategy across the supply chain: A conceptual approach from the organisational perspective. *Sustainability (Switzerland)*, *12*(24), 1–16. Scopus. https://doi.org/10.3390/su122410438

Nambisan, S. (2017). Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship. *Entrepreneurship: Theory and Practice*, *41*(6), 1029–1055. https://doi.org/10.1111/etap.12254

Napoleão, B., Souza, E., Ruiz, G., Felizardo, K., Meinerz, G., & Vijaykumar, N. (2021). Synthesizing researches on Knowledge Management and Agile Software Development using the Meta-ethnography method. *Journal of Systems and Software*, *178*, 110973. https://doi.org/10.1016/j.jss.2021.110973

Natalicchio, A., Ardito, L., Savino, T., & Albino, V. (2017). Managing knowledge assets for open innovation: A systematic literature review. *Journal of Knowledge Management*, *21*(6), 1362–1383. https://doi.org/10.1108/JKM-11-2016-0516

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

Nedelko, Z. (2021). What Drives the Usage of Management Tools Supporting Industry 4.0 in Organizations? *Sensors*, *21*(10), Article 10. https://doi.org/10.3390/s21103512

Nelson, R., Winter, & Sidney, G. (1982). *An Evolutionary Theory of Economic Change*. https://www.hup.harvard.edu/catalog.php?isbn=9780674272286

Newbert, S. L. (2007). Empirical research on the resource-based view of the firm: An assessment and suggestions for future research. *Strategic Management Journal*, *28*(2), 121–146. https://doi.org/10.1002/smj.573

Newell, A. (1982). The knowledge level. *Artificial Intelligence*, *18*(1), 87–127. https://doi.org/10.1016/0004-3702(82)90012-1

Noblet, J.-P., & Simon, E. (2012). The role of disseminative capacity in knowledge sharing: Which model can be applied to SMEs? *Problems and Perspectives in Management*, *10*, 57–66.

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, *5*(1), 14–37.

Nonaka, I., & Konno, N. (1998). The concept of 'Ba': Building a foundation for Knowledge creation. *California Review Management*, *40*(3), 40–54.

Nonaka, I., & Takeuchi, H. (1995). The Knowledge Creating. *New York*, *304*.

Nonaka, I., & Toyama, R. (2015). The Knowledge-creating Theory Revisited: Knowledge Creation as a Synthesizing Process. In J. S. Edwards (Ed.), *The Essentials of Knowledge Management* (pp. 95–110). Palgrave Macmillan UK. https://doi.org/10.1057/9781137552105_4

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, Ba and Leadership: A Unified Model of Dynamic Knowledge Creation. *Long Range Planning*, *33*, 5–34. https://doi.org/10.1016/S0024-6301(99)00115-6

Oks, S. J., Fritzsche, A., & Möslein, K. M. (2017). An Application Map for Industrial Cyber-Physical Systems. In S. Jeschke, C. Brecher, H. Song, & D. B. Rawat (Eds.), *Industrial Internet of Things: Cybermanufacturing Systems* (pp. 21–46). Springer International Publishing. https://doi.org/10.1007/978-3-319-42559-7_2

Olan, F., Suklan, J., Arakpogun, E. O., & Robson, A. (2021). Advancing Consumer Behavior: The Role of Artificial Intelligence Technologies and Knowledge Sharing. *IEEE Transactions on Engineering Management*, 1–13. https://doi.org/10.1109/TEM.2021.3083536

Pace, P., Aloi, G., Gravina, R., Caliciuri, G., Fortino, G., & Liotta, A. (2019). An Edge-Based Architecture to Support Efficient Applications for Healthcare Industry 4.0. *IEEE Transactions on Industrial Informatics*, *15*(1), 481–489. https://doi.org/10.1109/TII.2018.2843169

Paez-Logreira, H., Zamora-Musa, R., & Velez-Zapata, J. (2016). Relation Analysis of Knowledge Management, Research, and Innovation in University Research Groups. *Journal of Technology Management & Innovation*, *11*(4), Article 4. https://doi.org/10.4067/S0718-27242016000400002

Paluch, S., Brettel, M., Hopp, C., Piller, F., Salge, & Wentzler, D. (2017). Innovation in the digital age: From stage-gate to an agile development paradigm? *Journal of Business Research*.

Panahi, S., Watson, J., & Partridge, H. (2016). *Information encountering on social media and tacit knowledge sharing*. *42*(4), 539–550. https://doi.org/10.1177/0165551515598883

Pantic-Dragisic, S., & Söderlund, J. (2020). Swift transition and knowledge cycling: Key capabilities for successful technical and engineering consulting? *Research Policy*, *49*(1). https://ideas.repec.org//a/eee/respol/v49y2020i1s0048733319301994.html

Papa, A., Chierici, R., Ballestra, L. V., Meissner, D., & Orhan, M. A. (2020). Harvesting reflective knowledge exchange for inbound open innovation in complex collaborative networks: An empirical verification in Europe. *Journal of Knowledge Management*, *25*(4), 669–692. Scopus. https://doi.org/10.1108/JKM-04-2020-0300

Parisi, G. I., Kemker, R., Part, J. L., Kanan, C., & Wermter, S. (2019). Continual lifelong learning with neural networks: A review. *Neural Networks*, *113*, 54–71. https://doi.org/10.1016/j.neunet.2019.01.012

Patrucco, A., Harland, C. M., Luzzini, D., & Frattini, F. (2022). Managing triadic supplier relationships in collaborative innovation projects: A relational view perspective. *Supply Chain Management*. Scopus. https://doi.org/10.1108/SCM-05-2021-0220

Pellegrini, M., Ciampi, F., Marzi, G., & Orlando, B. (2020). The relationship between knowledge management and leadership: Mapping the field and providing future research avenues. *Journal of Knowledge Management*, *ahead-of-print*. https://doi.org/10.1108/JKM-01-2020-0034

Pérez-González, D., Trigueros-Preciado, S., & Popa, S. (2017). Social Media Technologies' Use for the Competitive Information and Knowledge Sharing, and

Its Effects on Industrial SMEs'. *Information Systems Management*, *34*(3), 291–303.

Pershina, R., Soppe, B., & Thune, T. M. (2019). Bridging analog and digital expertise: Cross-domain collaboration and boundary-spanning tools in the creation of digital innovation. *Research Policy*, *48*(9), Article 9. https://doi.org/10.1016/j.respol.2019.103819

Petticrew, M., & Roberts, H. (2006). Systematic Reviews in the Social Sciences: A Practical Guide. In *Systematic Reviews in the Social Sciences: A Practical Guide* (Vol. 11). https://doi.org/10.1002/9780470754887

Phawitpiriyakliti, C., Keawkunti, B., Saisama, C., & Sangma, W. (2020). TOWARDS ENVIRONMENTAL SUSTAINABILITY: A CASE STUDY OF GREEN SUPPLY CHAIN MANAGEMENT PRACTICE. *Journal of Security and Sustainability Issues*, *9*, 747–763. https://doi.org/10.9770/jssi.2020.9.3(2)

Pickernell, D. (1997). Less pain but what gain?: A comparison of the effectiveness and effects of Japanese and non-Japanese car assemblers' buyer-supplier relations in the UK automotive industry. *Omega*, *25*(4), 377–395.

Pieska. (2019). Fast Experimentations with Virtual Technologies Pave the Way for Experience Economy. *Acta Polytechnica Hungarica*, *16*(5), Article 5. https://doi.org/10.12700/APH.16.6.2019.6.2

Pittaway, L., & Cope, J. (2007). Entrepreneurship EducationA Systematic Review of the Evidence. *International Small Business Journal - INT SMALL BUS J*, *25*, 479–510. https://doi.org/10.1177/0266242607080656

Polanyi, M. (2015). *Personal Knowledge: Towards a Post-Critical Philosophy* (M. J. Nye, Ed.). University of Chicago Press. https://press.uchicago.edu/ucp/books/book/chicago/P/bo19722848.html

Pooley, A., & Chan, J. H. (2021). *A case study on performance assessment framework for Agile processes*. 14.

Poy, S., & Schüller, S. (2020). Internet and voting in the social media era: Evidence from a local broadband policy. *Research Policy*, *49*(1), 103861.

Prasad, S., & Sounderpandian, J. (2003). Factors influencing global supply chain efficiency: Implications for information systems. *Supply Chain Management: An International Journal*, *8*(3), 241–250. https://doi.org/10.1108/13598540310484636

Prior, D. D., Keränen, J., & Koskela, S. (2018). Sensemaking, sensegiving and absorptive capacity in complex procurements. *Journal of Business Research*, *88*, 79–90. Scopus. https://doi.org/10.1016/j.jbusres.2018.03.009

Puthiyamadam, T. (2017). How the Meaning of Digital Transformation Has Evolved. *Technology And Analytics*. https://hbr.org/2017/05/how-the-meaning-of-digital-transformation-has-evolved

Qiu, J., & Lv, H. (2014). An overview of knowledge management research viewed through the web of science (1993-2012). *Aslib Journal of Information Management*, *66*, 424–442. https://doi.org/10.1108/AJIM-12-2013-0133

Qu, S. Q., & Dumay, J. (2011). The qualitative research interview. *Qualitative Research in Accounting and Management*, *8*(3), 238–264. https://doi.org/10.1108/11766091111162070

Quarchioni, S., Paternostro, S., & Trovarelli, F. (2020). Knowledge management in higher education: A literature review and further research avenues. In *KNOWLEDGE MANAGEMENT RESEARCH & PRACTICE*. TAYLOR & FRANCIS LTD. https://doi.org/10.1080/14778238.2020.1730717

Quinn, E., Huckel-Schneider, C., Campbell, D., Seale, H., & Milat, A. J. (2014). How can knowledge exchange portals assist in knowledge management for evidence-informed decision making in public health? *BMC Public Health*, *14*(1), 443. https://doi.org/10.1186/1471-2458-14-443

Quintens, L., Pauwels, P., & Matthyssens, P. (2006). Global purchasing: State of the art and research directions. *Journal of Purchasing and Supply Management*, *12*(4), 170–181.

Quinton, S., & Wilson, D. (2016). Tensions and ties in social media networks: Towards a model of understanding business relationship development and business performance enhancement through the use of LinkedIn. *Industrial Marketing Management*, *54*. https://doi.org/10.1016/j.indmarman.2015.12.001

Qumer, A., & Henderson-Sellers, B. (2006). Comparative evaluation of XP and scrum using the 4d analytical tool (4-DAT). *Proceedings of the European and Mediterranean Conference on Information Systems, EMCIS 2006*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-35148896220&partnerID=40&md5=04b7257d25bc2e427bf8c914b3dcdec3

Rafi, M., JianMing, Z., & Ahmad, K. (2020). Digital resources integration under the knowledge management model: An analysis based on the structural equation model. *Information Discovery and Delivery*, *48*(4), Article 4. https://doi.org/10.1108/IDD-12-2019-0087

Ragab, M. A. F., & Arisha, A. (2013). Knowledge management and measurement: A critical review. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 17, Issue 6, pp. 873–901). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-12-2012-0381

Rainey, S. (2017). Simulation of Consciousness, and pragmatic accounting for language. *Proceedings of AISB Annual Convention 2017*, 399–402. https://scholar.google.it/scholar?q=Simulation+of+Consciousness,+and+pragmatic+accounting+for+language&hl=it&as_sdt=0&as_vis=1&oi=scholart

Rajabion, L., Mokhtari, A. S., Khordehbinan, M. W., Zare, M., & Hassani, A. (2019). The role of knowledge sharing in supply chain success Literature review, classification and current trends. In *JOURNAL OF ENGINEERING DESIGN AND TECHNOLOGY* (Vol. 17, Issue 6, pp. 1222–1249). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JEDT-03-2019-0052

Raji, I. O., Shevtshenko, E., Rossi, T., & Strozzi, F. (2021). Modelling the relationship of digital technologies with lean and agile strategies. *Supply Chain Forum: An International Journal*, *22*(4), Article 4. https://doi.org/10.1080/16258312.2021.1925583

Ramy, A., Af Ragab, M., & Arisha, A. (2018). Knowledge management in the pharmaceutical industry between academic research and industry regulations. In *KNOWLEDGE MANAGEMENT RESEARCH & PRACTICE*. TAYLOR & FRANCIS LTD. https://doi.org/10.1080/14778238.2020.1767517

Rana, G., & Sharma, R. (2019). Emerging human resource management practices in Industry 4.0. *Strategic HR Review*, *18*(4), 176–181. https://doi.org/10.1108/SHR-01-2019-0003

Raudeliūnienė, J., Davidavičienė, V., & Petrusevičius, R. (2018). Factors influencing knowledge retention process: Case of Lithuanian armed forces. *Technological and Economic Development of Economy*, *24*(3), Article 3. https://doi.org/10.3846/20294913.2017.1309598

Rebs, T., Brandenburg, M., & Seuring, S. (2019). System dynamics modeling for sustainable supply chain management: A literature review and systems thinking approach. *Journal of Cleaner Production*, *208*, 1265–1280. https://doi.org/10.1016/j.jclepro.2018.10.100

Rechberg, I., & Syed, J. (2014). Knowledge Management Practices and the Focus on the Individual. *International Journal of Knowledge Management*, *10*, 26–42. https://doi.org/10.4018/ijkm.2014010102

Rêgo, B. S., Jayantilal, S., Ferreira, J. J., & Carayannis, E. G. (2022). Digital Transformation and Strategic Management: A Systematic Review of the Literature. *Journal of the Knowledge Economy*, *13*(4), 3195–3222. https://doi.org/10.1007/s13132-021-00853-3

Rialti, R., Marzi, G., Ciappei, C., & Busso, D. (2019). Big data and dynamic capabilities: A bibliometric analysis and systematic literature review. In *MANAGEMENT DECISION* (Vol. 57, Issues 8, SI, pp. 2052–2068). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/MD-07-2018-0821

Ribiere, V. M., & Tuggle, F. D. (Doug). (2010). Fostering innovation with KM 2.0. *VINE*, *40*(1), Article 1. https://doi.org/10.1108/03055721011024955

Rigby, D. K., Sutherland, J., & Takeuchi, H. (2016). Embracing agile. *Harvard Business Review*, *2016*(May). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85004130234&partnerID=40&md5=00fbb1ad10ed0b336929feb93186cc1d

Rodriguez, M., & Martius, V. (2013). *Gestão do conhecimento e inovação nas empresas.* (1st ed.). https://www.passeidireto.com/arquivo/88925312/gestao-do-conhecimento-1

Roos, G., & Roos, J. (1997). Measuring your company's intellectual performance. *Long Range Planning*, *30*(3), 413–426. https://doi.org/10.1016/S0024-6301(97)90260-0

Rossini, M., Cifone, F. D., Kassem, B., Costa, F., & Portioli-Staudacher, A. (2021). Being lean: How to shape digital transformation in the manufacturing sector. *Journal of Manufacturing Technology Management*, *32*(9), 239–259. Scopus. https://doi.org/10.1108/JMTM-12-2020-0467

Russell, S. J.; Norvig, P. (2003). *Artificial Intelligence: A Modern Approach* (2nd ed.). Prentice Hall.

Saaty, T. L. (1984). The Analytic Hierarchy Process: Decision Making in Complex Environments. In R. Avenhaus & R. K. Huber (Eds.), *Quantitative Assessment in Arms Control: Mathematical Modeling and Simulation in the Analysis of Arms Control Problems* (pp. 285–308). Springer US. https://doi.org/10.1007/978-1-4613-2805-6_12

Sako, M. (1992). *Price, Quality and Trust: Inter-firm Relations in Britain and Japan*. Cambridge University Press.

Saldaña, J. (2009). *The Coding Manual for Qualitative Researchers*. Sage.

Santarsiero, F., Lerro, A., Carlucci, D., & Schiuma, G. (2020). *Modelling and managing innovation lab as catalyst of digital transformation: Theoretical and empirical evidence*. 12.

Saratchandra, M., & Shrestha, A. (2022). The role of cloud computing in knowledge management for small and medium enterprises: A systematic literature review. *Journal of Knowledge Management*. Scopus. https://doi.org/10.1108/JKM-06-2021-0421

Schniederjans, D. G., Curado, C., & Khalajhedayati, M. (2020). *Supply chain digitisation trends: An integration of knowledge management*. https://doi.org/10.1016/J.IJPE.2019.07.012

Schrettle, S., Hinz, A., -Rathje, M. S., & Friedli, T. (2014). Turning sustainability into action: Explaining firms' sustainability efforts and their impact on firm performance. *International Journal of Production Economics*, *147*, 73–84.

Schwarzmüller, T., Brosi, P., Duman, D., & Welpe, I. M. (2018). How does the digital transformation affect organizationsorganisations? Key themes of change in work design and leadership. *Management Revue*, *29*(2), 114–138. https://doi.org/10.5771/0935-9915-2018-2-114

Scuotto, V., Caputo, F., Villasalero, M., & Giudice, M. (2017). A multiple buyer – supplier relationship in the context of SMEs' digital supply chain management. *Production Planning & Control*, *28*, 1378–1388. https://doi.org/10.1080/09537287.2017.1375149

Secundo, G., Ndou, V., Del Vecchio, P., & De Pascale, G. (2019). Knowledge management in entrepreneurial universities A structured literature review and avenue for future research agenda. In *MANAGEMENT DECISION* (Vol. 57, Issues 12, SI, pp. 3226–3257). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/MD-11-2018-1266

Sedita, S. R., Hoffmann, V. E., Guarnieri, P., & Toso Carraro, E. (2021). Prosecco has another story to tell: The coexistence of multiple knowledge networks in the same value chain. *International Journal of Wine Business Research*, *33*(4), 502–522. Scopus. https://doi.org/10.1108/IJWBR-06-2020-0024

Senapathi, M., & Srinivasan, A. (2012). Understanding post-adoptive agile usage: An exploratory cross-case analysis. *Journal of Systems and Software*, *85*(6), 1255–1268. https://doi.org/10.1016/j.jss.2012.02.025

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16*(15), 1699–1710. https://doi.org/10.1016/j.jclepro.2008.04.020

Shahzad, A., Hassan, R., Aremu, A. Y., Hussain, A., & Lodhi, R. N. (2021). Effects of COVID-19 in E-learning on higher education institution students: The group comparison between male and female. *Quality & Quantity*, *55*(3), 805–826. https://doi.org/10.1007/s11135-020-01028-z

Sharma, R., Kamble, S. S., Gunasekaran, A., Kumar, V., & Kumar, A. (2020). A systematic literature review on machine learning applications for sustainable agriculture supply chain performance. *Computers & Operations Research*, *119*, 104926. https://doi.org/10.1016/j.cor.2020.104926

Sharma, S., Singh, G., Jones, P., Kraus, S., & Dwivedi, Y. K. (2022). Understanding Agile Innovation Management Adoption for SMEs. *IEEE Transactions on Engineering Management*, 1–12. https://doi.org/10.1109/TEM.2022.3148341

Siachou, E., Trichina, E., Papasolomou, I., & Sakka, G. (2021). Why do employees hide their knowledge and what are the consequences? A systematic literature review.

Journal of Business Research, *135*, 195–213. https://doi.org/10.1016/j.jbusres.2021.06.031

Siggelkow, N. (2007). Persuasion with case studies. *Academy of Management Journal*, *50*(1), 20–24. https://doi.org/10.5465/AMJ.2007.24160882

Sikos, L. (2017). Description Logics in Multimedia Reasoning. In *Description Logics in Multimedia Reasoning*. https://doi.org/10.1007/978-3-319-54066-5

Singh, A., Singh, K., & Sharma, N. (2014). Agile knowledge management: A survey of Indian perceptions. *Innovations in Systems and Software Engineering*, *10*(4), Article 4. https://doi.org/10.1007/s11334-014-0237-z

Sohn, S., Kocher, J.-P. A., Chute, C. G., & Savova, G. K. (2011). Drug side effect extraction from clinical narratives of psychiatry and psychology patients. *Journal of the American Medical Informatics Association: JAMIA*, *18 Suppl 1*(Suppl 1), i144-149. https://doi.org/10.1136/amiajnl-2011-000351

Solaimani, S., & Van der Veen, J. (2021). Open supply chain innovation: An extended view on supply chain collaboration. *Supply Chain Management*. https://doi.org/10.1108/SCM-09-2020-0433

Stock, J., & Boyer, S. (2009). Developing a Consensus Definition of Supply Chain Management: A Qualitative Study. *International Journal of Physical Distribution and Logistics Management*, *39*(8). https://digitalcommons.bryant.edu/mark_jou/29

Stornelli, A., Ozcan, S., & Simms, C. (2021). Advanced manufacturing technology adoption and innovation: A systematic literature review on barriers, enablers, and innovation types. *Research Policy*, *50*(6), 104229. https://doi.org/10.1016/j.respol.2021.104229

Strozzi, F., Colicchia, C., Creazza, A., & Noè, C. (2017). Literature review on the 'Smart Factory' concept using bibliometric tools. *International Journal of Production Research*, *55*(22), 6572–6591. https://doi.org/10.1080/00207543.2017.1326643

Szász, L., & Demeter, K. (2015). Business models along supply chain position and servitisation: An empirical investigation of European manufacturers. *Acta Oeconomica*, *65*(3), 367–391. Scopus. https://doi.org/10.1556/032.65.2015.3.2

Szász, L., Demeter, K., Rácz, B.-G., & Losonci, D. (2021). Industry 4.0: A review and analysis of contingency and performance effects. *Journal of Manufacturing Technology Management*, *32*(3), 667–694. Scopus. https://doi.org/10.1108/JMTM-10-2019-0371

Telles, R., Arten, F. T., de Queiroz, M. M., & Carneiro-Da-Cunha, J. A. (2020). Knowledge and innovation diffusion in retailing clusters: An analysis based on the social perspective. *International Journal of Knowledge-Based Development*, *11*(3), 268–287. Scopus. https://doi.org/10.1504/IJKBD.2020.112800

Teoh, S. Y., & Cai, S. (2015). The Process of Strategic, Agile, Innovation Development: A Healthcare Systems Implementation Case Study. *Journal of Global Information Management*, *23*(3), Article 3. https://doi.org/10.4018/JGIM.2015070101

Terentyeva, I., Lunev, A., Kashina, S., Sadrieva, L., Korolyuk, I., & Pugacheva, N. (2020). The Virtual Construction Site: Knowledge Management in Virtual Environments. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(13), Article 13. https://doi.org/10.3991/ijet.v15i13.14655

Thomas, J., Kellogg, W., & Erickson, T. (2001). The knowledge management puzzle: Human and social factors in knowledge management. *IBM Systems Journal*, *40*, 863–884. https://doi.org/10.1147/sj.404.0863

Thomas, M., & Thomas, H. (2012). Using new social media and Web 2.0 technologies in business school teaching and learning. *Journal of Management Development*, *31*(4), 358–367. https://doi.org/10.1108/02621711211219013

Timinger, H., Schmidtner, M., & Reiche, F. (2022). A Framework for the Construction and Tailoring of Engineering Development Process Models. *IEEE Transactions on Engineering Management*, 1–22. https://doi.org/10.1109/TEM.2021.3132699

Tønnessen, Ø., Dhir, A., & Flåten, B.-T. (2021). Digital knowledge sharing and creative performance: Work from home during the COVID-19 pandemic. *Technological Forecasting and Social Change*, *170*, 120866. https://doi.org/10.1016/j.techfore.2021.120866

Torres, R., Sidorova, A., & Jones, M. C. (2018). Enabling firm performance through business intelligence and analytics: A dynamic capabilities perspective. *Information & Management*, *55*(7), 822–839. https://doi.org/10.1016/j.im.2018.03.010

Townsend, M., Le Quoc, T., Kapoor, G., Hu, H., Zhou, W., & Piramuthu, S. (2018). Real-Time business data acquisition: How frequent is frequent enough? *Information & Management*, *55*(4), 422–429. https://doi.org/10.1016/j.im.2017.10.002

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, *14*, 207–222. https://doi.org/10.1111/1467-8551.00375

Tseng, S.-M., & Lee, P.-S. (2014). The effect of knowledge management capability and dynamic capability on organizational performance. *Journal of Enterprise*

Information Management, *27*(2), 158–179. https://doi.org/10.1108/JEIM-05-2012-0025

Tsouri, M., Hanson, J., & Normann, H. E. (2021). Does participation in knowledge networks facilitate market access in global innovation systems? The case of offshore wind. *Research Policy*, *50*(5), 104227. https://doi.org/10.1016/j.respol.2021.104227

Tuptuk, N., & Hailes, S. (2018). Security of smart manufacturing systems. *Journal of Manufacturing Systems*, *47*. https://doi.org/10.1016/j.jmsy.2018.04.007

Umar, M., Wilson, M. M. J., & Heyl, J. E. (2021). The structure of knowledge management in inter-organisational exchanges for resilient supply chains. *J. Knowl. Manag.* https://doi.org/10.1108/JKM-06-2020-0488

Uren, V., Cimiano, P., Iria, J., Handschuh, S., Vargas-Vera, M., Motta, E., & Ciravegna, F. (2006). Semantic annotation for knowledge management: Requirements and a survey of the state of the art. *Journal of Web Semantics*, *4*(1), 14–28. https://doi.org/10.1016/j.websem.2005.10.002

Usai, A., Pironti, M., Mital, M., & Mejri, C. A. (2018). Knowledge discovery out of text data: A systematic review via text mining. In *JOURNAL OF KNOWLEDGE MANAGEMENT* (Vol. 22, Issue 7, pp. 1471–1488). EMERALD GROUP PUBLISHING LTD. https://doi.org/10.1108/JKM-11-2017-0517

Vachon, S., & Klassen, R. D. (2008). Environmental management and manufacturing performance: The role of collaboration in the supply chain. *International Journal of Production Economics*, *111*(2), 299–315.

van Kooij, E. (1991). Japanese subcontracting at a crossroads. *Small Business Economics*, *3*(2), 145–154. https://doi.org/10.1007/BF00388448

Van Maanen, J. (1979). The fact of fiction in organizational ethnography. *Administrative Science Quarterly*, *24*(4), 539–550.

Vanitha, S., Balasubramanie, P., Arvind, K. S., Niveditha, V. R., & Elumalai, S. (2020). INTERNET OF THINGS: A REVIEW ON THEIR REQUISITE IN THE DIGITAL ERA. *International Journal of Advanced Science and Technology*, *29*(9), 591–602.

Venkatraman, N., & Tanriverdi, H. (2004). REFLECTING 'KNOWLEDGE' IN STRATEGY RESEARCH: CONCEPTUAL ISSUES AND METHODOLOGICAL CHALLENGES. *Research Methodology in Strategy and Management*, *1*, 33–65. Scopus. https://doi.org/10.1016/S1479-8387(04)01102-6

Vestal, A., & Danneels, E. (2018). Knowledge exchange in clusters: The contingent role of regional inventive concentration. *Research Policy*, *47*(10), 1887–1903. https://doi.org/10.1016/j.respol.2018.06.020

Walsham, G. (1995). Interpretive case studies in IS research: Nature and method. *European Journal of Information Systems*, *4*(2), 74–81. https://doi.org/10.1057/ejis.1995.9

Wang, C. L., Hult, G. T. M., Ketchen, D. J., & Ahmed, P. K. (2009). Knowledge management orientation, market orientation, and firm performance: An integration and empirical examination. *Journal of Strategic Marketing*, *17*(2), 99–122. Scopus. https://doi.org/10.1080/09652540902879326

Wang, X., Conboy, K., & Cawley, O. (2012). 'Leagile' software development: An experience report analysis of the application of lean approaches in agile software development. *Journal of Systems and Software*, *85*(6), 1287–1299. https://doi.org/10.1016/j.jss.2012.01.061

Wang, Y., Blache, R., Zheng, P., & Xu, X. (2018). A Knowledge Management System to Support Design for Additive Manufacturing Using Bayesian Networks. *Journal of Mechanical Design*, *140*(5). https://doi.org/10.1115/1.4039201

Wang, Y., Rod, M., Ji, S., & Deng, Q. (2017). Social media capability in B2B marketing: Toward a definition and a research model. *Journal of Business & Industrial Marketing*, *32*(8), 1125–1135. https://doi.org/10.1108/JBIM-10-2016-0250

Wang, Y., Yan, F., Jia, F., & Chen, L. (2021). Building supply chain resilience through ambidexterity: An information processing perspective. *International Journal of Logistics Research and Applications*. Scopus. https://doi.org/10.1080/13675567.2021.1944070

Weaven, S., Grace, D., Dant, R., & R. Brown, J. (2014). Value creation through knowledge management in franchising: A multi-level conceptual framework. *Journal of Services Marketing*, *28*(2), 97–104. https://doi.org/10.1108/JSM-09-2013-0251

Weick, K. E. (1995). *Sensemaking in Organizations*. SAGE.

Weinreich, R., & Groher, I. (2016). Software architecture knowledge management approaches and their support for knowledge management activities: A systematic literature review. In *INFORMATION AND SOFTWARE TECHNOLOGY* (Vol. 80, pp. 265–286). ELSEVIER. https://doi.org/10.1016/j.infsof.2016.09.007

Wenger, E. (1999). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press.

Williamson, O. E. (1979). Transaction-Cost Economics: The Governance of Contractual Relations. *The Journal of Law & Economics*, *22*(2), 233–261.

Womack, J. P., Jones, D. T., & Roos, D. (2007). *The Machine That Changed the World: The Story of Lean Production-Toyota's Secret Weapon in the Global Car Wars that is Revolutionizing World Industry: ... That Is Now Revolutionizing World Industry* (Reprint edizione). Free Pr.

Wong, A. (1999). Partnering through cooperative goals in supply chain relationships. *Total Quality Management*, *10*(4–5), 786–792. https://doi.org/10.1080/0954412997811

Wong, K., Tan, L., Lee, C., & Wong, W. (2013). Knowledge Management performance measurement: Measures, approaches, trends and future directions. *Information Development*, *31*. https://doi.org/10.1177/0266666913513278

Xu, Z., Luo, X., Zhang, S., Wei, X., Mei, L., & Hu, C. (2014). Mining temporal explicit and implicit semantic relations between entities using web search engines. *Future Generation Computer Systems*, *37*, 468–477. https://doi.org/10.1016/j.future.2013.09.027

Xue, L., Ray, G., & Sambamurthy, V. (2013). The impact of supply-side electronic integration on customer service performance. *Journal of Operations Management*, *31*(6), 363–375. https://doi.org/10.1016/j.jom.2013.07.010

Yan, E., & Ding, Y. (2012). Scholarly network similarities: How bibliographic coupling networks, citation networks, cocitation networks, topical networks, coauthorship networks, and coword networks relate to each other. *Journal of the American Society for Information Science and Technology*, *63*(7), 1313–1326. https://doi.org/10.1002/asi.22680

Yang, J., Wong, C. W. Y., Lai, K., & Ntoko, A. N. (2009). The antecedents of dyadic quality performance and its effect on buyer-supplier relationship improvement. *International Journal of Production Economics*, *120*(1), 243–251.

Yanzer Cabral, A. R., Ribeiro, M. B., & Noll, R. P. (2014). Knowledge Management in Agile Software Projects: A Systematic Review. *Journal of Information & Knowledge Management*, *13*(01), Article 01. https://doi.org/10.1142/S0219649214500105

Yin, R. (1984). *Case study research*. Sage.

Yin, R. K. (2009). *Case Study Research: Design and Methods*. SAGE.

Zahra, S. A., & George, G. (2002). The Net-Enabled Business Innovation Cycle and the Evolution of Dynamic Capabilities. *Information Systems Research*, *13*(2), 147–150. https://doi.org/10.1287/isre.13.2.147.90

Zanasi, A. (2009). Virtual Weapons for Real Wars: Text Mining for National Security. In E. Corchado, R. Zunino, P. Gastaldo, & Á. Herrero (Eds.), *Proceedings of the International Workshop on Computational Intelligence in Security for Information Systems CISIS'08* (pp. 53–60). Springer. https://doi.org/10.1007/978-3-540-88181-0_7

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

Zhou, M., Leenders, M. A. A. M., & Cong, L. M. (2018). Ownership in the virtual world and the implications for long-term user innovation success. *Technovation*, *78*, 56–65. Scopus. https://doi.org/10.1016/j.technovation.2018.06.002

10 ACKNOWLEDGEMENTS

"People are what they eat," the philosopher Feuerbach said, breaking the dualism between soul and body that had existed in Western philosophy since the time of the ancient Greeks, merging the two parts of the human being into a single material inseparable entity. However, this cannot lead to a purely historical and atheistic materialism of man as a machine made of pure flesh; in fact, Aristotle's assumption, "man is a social animal," is constantly experienced daily by each of us in search of a sociality (in a real or virtual world) to be able to feed on emotions, the food of the soul.

The importance of these stimuli is also supported by dynamic systems theories, which state that any system forced differently has different evolutions that are more difficult to predict as the forced system becomes more complex... and the human being is undeniably a complex system.

As a result, after this long last period as a student, I can only thank everyone who has crossed paths with me and shared positive emotions with me to feed on when the world around me... us... has become a big black hole of emotion.

To Roberto and Piera, who have chosen me to carry out their goal of creating a capable, trustworthy, and united working group, for giving my determination (still alive after so many years away from the academy) that confidence that not all mastered is granted. I didn't bring hierarchical respect, and you didn't ask for it, but our honesty and respect for each other in our group have taken us equally far, collecting relevant results that not everyone does.

To Daniele, who mends a broken heart, and to Roberto, who reopens my soul's eyes to beauty. Without your aid, I doubt I would have been able to face everything that was about to overwhelm me.

To Luigi, who, even when far off the distance, has always been close to me, supporting me, putting up with me, and encouraging me to do my best, because all I needed was someone who believed in me and made me realise that, after all, I believed in myself too. The personal evolution you accompanied me through between those beautiful corners of Bergamo and Turin was as crucial as the scientific evolution of the last three years of study.

To Davide, on the other hand, who accompanied my emotional growth even when I didn't understand, even when there seemed to be no way out, even when I felt alone in the battle... Without judging, he brought me closer to myself and helped me make sustainable decisions for me... then it's not my issue for the others.

Survival cafés would not have tasted the same without you, Stefano and Emanuela, excellent companions in writing and travel misadventures.

To Amedeo, who reminded me that professionalism doesn't have to imply coldness but that you can be accomplices until you become friends, especially if you're dealing with pizza or wine.

To Michele, Alessandro, and Antonio, who helped me accept and grow my mind and soul in a body of the same level.

To Pasquale, who, against the beautiful backdrop of Paris, gave me the new perspectives that the pandemic had taken away.

To Marina and Andrea, who never stop reminding me how positive I am and how I manage to face every situation by looking for the positives and possibilities...problems can come later. When the world teaches you only to see problems and flaws and then judges you... It would have taken a long time for me to lose this quality without you.

To Amedeo Roberto, who reminded me, in the most stormy moment of my journey, when I felt alone and all faith... and trust creaked, dissolving in the cold winter wind, that faith...or trust (if there is ever a difference) begins with self and that any stormy sea can be overcome.

There have also been people who, more or less assiduously and voluntarily, have not tried to help me because of their selfish or negative attitudes... But, recalling Dumbledore's words at King's Cross, I can't help but "feel pity for the living who live without love" and thank myself for being able to contain this negativity and value all my best qualities as well as the support I've received.

After all, this has been a journey of many difficulties and trials, but also of surprising results, of much love and affection. Short or long, intense or distributed, wanted or spontaneous, it was evident at every moment to look at your support in a path that traditionally is a path of abandonment, of transformation... even more so because it was faced during a pandemic period in which we were also forced to physical distance, to detach before I was even emotionally and professionally ready to remain alone, limiting my best qualities. The doctorate was a path in which the scientific and professional growth obtained was only second to the personal growth that I have carried out ... and it is precisely this soul training that will lay the foundations for the future researcher that I will be.

I'm not sure how many people will understand what I said because, as Galiano wrote, "the fact is that you can only say certain things to those you know who can understand them, which is also why we talk so little about what really matters to us". But if you don't take the risk of feeding your emotions to others, you'll probably never be able to make people appreciate flavours and emotions that nourish the flesh and soul with something better... and find others who care about what we care about and make us happy. Finally, replacing chocolate and ron with pure personal endorphins is far more sustainable in terms of economic, environmental, and social sustainability...

So, for this goal achieved and for the next ones I will reach, thanks to me and thanks to you!