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Knowledge and ICT based networks: towards a taxonomy

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Abstract ***Purpose.*** *The article proposes a taxonomy of knowledge-based and information and communication technology (ICT) networks based on a systematic literature review. The specific objectives focus on (1) presenting knowledge-based and ICT network models, indicating their theoretical context (trends); (2) identifying proposals for knowledge-based network models in the literature (based on SLR); (3) developing a taxonomy of knowledge-based network models; and (4) indicating the directions of their development.*
Design/methodology/approach. *The systematic literature review (SLR) methodology was used, which allows not only for a formalized and objectified synthesis of the existing scientific achievements or for the evaluation of previous research. In addition, the "snowball" method was used, and its application was supported by the use of the ResearchRabbit tool. In addition, the taxonomy method (typological analysis, typological approach) was used.*
Findings. *The results of SLR were presented: a list of selected types of knowledge-based and ICT networks along with a discussion of the results, and the author's proposals for a taxonomy of knowledge-based and ICT networks were presented along with a synthetic description of the leading models. The directions of their development were also indicated.*
Practical implications. *(*if any, optional). The practical usefulness of the proposal contained in the study is related to the possibility of using the proposed concept to evaluate various types of network models, which will enable the formulation of diagnostic findings and conducting comparative and dynamic research in the field of analysis and evaluation of knowledge-based and ICT-based network models.*
Originality/value. *The added value of the article is related to the development of a proprietary taxonomy of knowledge- and ICT-based networks and, consequently, to the organization and systematization of models of these networks. This taxonomy is a valuable tool for organizing and categorizing information systematically. When it comes to knowledge and ICT-based networks, a taxonomy can help classify and understand the different types and components involved in starting point division into network models that were created as a result of the virtualization process and models that were created as a result of exchange processes and the flow of intangible assets. The added value is also related to the practical usefulness of the developed taxonomy.*

Keywords organizational networks, taxonomy, knowledge, ICT, knowledge-based networks and ICT

INTRODUCTION

Modern organizations increasingly notice the need for cooperation between entities with various complementary resources and competencies. An organization's competitiveness on the global and local market is determined by the ability to acquire and absorb appropriate knowledge and the ability to use it. Knowledge management is essential in the case of network organizations that build their potential through the proper use of tangible and intangible resources and improve the interactive learning process. The key task for network managers is to stimulate the flow of knowledge between various entities (Czakon, 2012).

Improving the flow of knowledge is conducive to spreading knowledge and stimulating the willingness to share knowledge affects the level of innovation.

The subject of research in this article are knowledge-based and information and communication technology (ICT)-based network models, which should be understood as those forms of cooperation (networks) that use existing knowledge resources, but also renew and update them all the time. Thanks to knowledge-based management, they strengthen their position in the local and

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global markets. Thanks to work performed, they are a set of interrelated elements of resources, which will be transformed into a new state of affairs—thanks to the possibilities of specific means and forces to create new values.
In the discussion on network theory in the literature, strong references are made to using various network models in management sciences (Borgatti & Halgin, 2011; Krzakiewicz & Cyfert, 2013). In most cases, the authors take the position that there is no universal network theory in management, and what theory is the basis for network research defined by researchers is determined by the purpose and the selected network model (Światowiec-Szczepańska & Kawa, 2018). Although much space has been devoted to knowledge management in networks in recent years, a research gap related to the organization and systematization of knowledge-based and ICT-based network models can be noticed.
Considering the existing cognitive gap, this article presents an overview of proposals in the field of knowledge-based network models in the literature and the taxonomy of knowledge-based network models and ICT. Taxonomies are valuable tools for organizing and categorizing information systematically. When it comes to knowledge and ICT-based networks, a taxonomy can help classify and understand the different types and components involved. The considerations were based on the analysis of the literature on the subject, both domestic and foreign, and the data sources were publications contained in the Web of Science and Scopus databases. In addition to the analysis of literature sources, my research was based on qualitative research, the aim of which was to identify types of knowledge-based and ICT-based network models. The primary research method is the method of taxonomy (typological analysis, typological approach), where taxonomy is understood here as a division of particular objects into groups characterized by a pervasive feature or a group of characteristics—constituting a specific type.
The main problem focuses on finding proposes a taxonomy of knowledge-based and ICT networks based on a systematic literature review. The specific objectives focus on (1) presenting knowledge-based and ICT network models, indicating their theoretical context (trends); (2) identifying proposals for knowledge-based network models in the literature (based on systematic literature review [SLR]); (3) developing a taxonomy of knowledge-based network models; and (4) indicating the directions of their development.
The central part of the article is a proposal for a taxonomy of knowledge-based network models and their analysis. The starting point was the adoption of two assumptions:
(1) The use of tangible and intangible resources and the improvement of the interactive learning process are now becoming crucial for the functioning of the network.(2) Taxonomies play an important role in theory building.
The first part of the article presents the essence of networks based on knowledge and ICT, indicating their theoretical context (trends). Then, an SLR was carried out to identify proposals for knowledge-based network models in the literature. Next, the typology and characteristics of knowledge-based network models were presented, and the directions of their development were indicated.

BACKGROUND

The concept of „network" is now a central concern in many fields, including social sciences, communications, computer science, physics, and even biology and ecosystems (Dorogovtsev & Mendes, 2003; Drucker, 1988; Miles & Snow, 1986; Wasserman & Faust, 1994). The roots of network science, network theory, social network theory, and social network analysis come from social psychology, sociology, and anthropology, in which the network perspective allows to formulate research questions about systems human, biological, or economic. A strong presence in network science is occupied by graph theory, related matrix algebra, and network statistics. Currently, networks permeate science, technology, and business, and understanding the complexity of a system understood as a whole composed of a set of things (elements) working together as parts of a mechanism or connected networks, is not possible without a deeper analysis of the network of relationships and connections that make up a given system (Barabási, 2009).
An organizational network is a system of relations (connections) of an external and internal nature between the components of the network, that is, organizational units (e.g., departments, departments) and independent entities (e.g., enterprises, public organizations). In practice, this means linking elements of various organizations and institutions into different network combinations (depending on the needs), and their number and nature are determined by the number and type of relations between the network components (Barczak 2020). An organizational network is described through its structure (nodes and connections), dynamics, and behaviors, which is why most research focuses on the network representations' structural and dynamic properties.
Networks based on knowledge and ICT are a category of models of organizational networks, the source of which is the belief that knowledge and learning processes are crucial for the development of modern organizations. They are the most

current stage of the organization's improvement process. Such a network functions to use existing knowledge resources and constantly renew and update them. In doing so, it maintains its competitive position in the market. Thanks to knowledge-based management, it also strengthens its part in the local and global markets.
In network models based on knowledge and ICT, the key to organizational success is to focus efforts on acquiring and transforming existing knowledge resources into new knowledge, implemented in the form of technologies, inventions, products, methods, and procedures (Barczak, 2020, 2021). The diagram of connections in such networks is shown in Fig. 1.

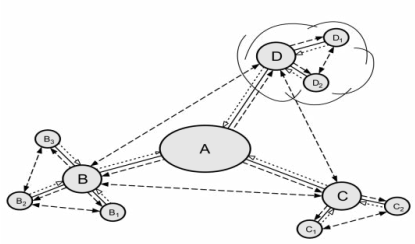


Figure 1. Scheme of connections in a network based on knowledge and ICT
Source: Own work

Legend:
organizational relations
fer of the integrator's knowledge to cooperators
ack
ledge flow between cooperators

These models are characteristic of (1) the era of the knowledge-based economy (KBE), where information and knowledge are the company's essential resources; and (2) the era of industry 4.0, in which enterprises will create global networks, covering machines, storage systems, and production plants in the form of cyber-physical systems. In network models related to the KBE and Industry 4.0, the following factors become significant factors in gaining a competitive advantage (Perechuda, 2005):
- having essential competencies of a distinctive character,
- appropriate selection of partners,
- securing the impact of classified knowledge,
- selection of appropriate information and communication technologies, and
- self-creation of knowledge.

The development of information technologies leads to positive feedback, as the use of knowledge-based technologies leads to faster creation of knowledge, the absorption, and application of which, in turn, requires further development of knowledge. In the literature on the subject, when characterizing this category of networks, such concepts as intelligent organizations or learning organizations are often referred to. Senge (Senge, 1990) believes that the ability to learn quickly may soon become the only sustainable competitive advantage. The learning process is how an organization accumulates and disseminates the experience gained. Thanks to it, it is possible to achieve continuous improvements. Learning processes play a unique, positive role in building the organization's effectiveness, allowing for the dissemination and internalization of new experiences and solutions, primarily among the organization's members (Nesterowicz, 2001). Organizational learning is the adaptive behavior of the company, which means that depending on changes in the environment, the company changes its goals and criteria for evaluating the efficiency and considers new elements. This behavior takes the form of the company's response to internal and external changes. In the learning organization, there are learning processes necessary to make, for example, transformational changes or changes in organizational culture (basic assumptions and values) that organizations need in the current rapidly changing, often chaotic environment. In other words, in a learning organization, essential and even necessary learning to adapt or correct is supplemented by learning to find new solutions and expand creative possibilities.
Knowledge-based and ICT-based networks strongly correspond with trends that stem from the belief that knowledge and learning processes are crucial for the development of modern organizations. Three strands can be identified: knowledge management (KM), organizational learning, and learning organizations.
KM is a relatively young field of management with rich roots. Wiig (Wiig, 1997a, 1997b) was the first researcher to use the term and then to set a practical framework for the discipline. According to him, the overall goal of knowledge management is to maximize the effectiveness of knowledge-related activities. This goal consists of four fields of activity: (1) monitoring and

facilitating knowledge-related activities; (2) creating and updating knowledge infrastructure; (3) creating, renewing, building, and organizing knowledge assets; and (4) distributing and effective use of these assets (Wiig, 1997b). The main advantage of this trend is the emphasis on the value of knowledge in the processes of development and competitiveness, as well as the organization of the conceptual apparatus in this sphere: first of all, the distinction between tacit and explicit knowledge, strategic and operational knowledge, and the indication of different mechanisms that guide the building and transfer of its resources.
The concept of organizational learning (learning of the whole institution) was proposed by R. Cyert and J. March (Cyert & March, 1963), and then in 1978, it was developed by C. Argyris and D.A. Schön (1996) , (Rhodes, 1998). These first authors built the foundations of behavioral analysis in organizations. They proposed a general theory of organizational learning as part of firms' decision-making processes. In their works, they strongly emphasized the role of rules, procedures, and organizational routines that are both a tool for adaptation to the environment and a way for the organization to remember effective methods of operation.
While the stream of organizational learning can be perceived as process and descriptive, the concept of a learning organization is a stream that focuses on things, describing them in normative and prescriptive terms. The term „learning organization" was coined in the early 1990s based on European management literature. Still, the undoubted creator of the „brand" of a learning organization is P. Senge, the author of *The Fifth Discipline*. A significant achievement of this trend (especially about the concept of organizational network) is the translation of systems theory into a language understandable for managers—the language of the everyday dynamics of the organization. Learning organizations introduced the issues of feedback, the complexity of phenomena, and a holistic view of the problems and processes in which companies participate in everyday awareness.
The issues related to knowledge creation, collective learning, and virtual world interactions are extensive and dynamically developing (Benkler, 2006; Nonaka & Konno, 1998; Nonaka & Takeuchi, 1995). The creation of knowledge in intra-organizational and inter-organizational networks is a complex process consisting of acquiring, processing, sharing, and using information and experiences to generate new knowledge. This includes both explicit and tacit knowledge. In both cases, communication, openness to new ideas, and the ability to transform information into practical solutions play a key role. Knowledge creation in these networks can increase innovation, efficiency, and competitiveness in the organization.

METHOD

The methodology of the SLR was used, which allows not only for a formalized and objectified synthesis of the existing scientific achievements or the assessment of previous research (Gimenez & Tachizawa, 2012), but above all, it enables the identification of both researched and unexplored areas (Levy & J. Ellis, 2006).
The process of systematic literature review, underlying the search for and analysis of the existing divisions of knowledge-based and ICT networks, was carried out in three stages (Anello & Fleiss, 1995) starting from creating a literature database (stage I), through a selection of works finally included in the database (stage II), ending with a critical analysis of the content (stage III). In the case of the undertaken research, the most general approach was adopted, that is, based on scientific bases. This approach resulted from the fact that due to the wide range of topics the research project covers, it would be difficult to identify the most important journals. Scopus and the Web of Science (WoS) were chosen as data sources because they are comprehensive and reliable databases and contain full texts and cited references from the most famous journals.
Before identifying existing scientific publications, defining the criteria for the automated search of works in electronic databases is necessary. The advantage of a systematic review of the literature is the protection of the process of selecting publications for analysis against:
– each time subjective assessment of the researcher,
– the effect of fatigue,
– systematic omission of certain items of literature,
– preference for specific trends in literature, and
– lack of knowledge of research in particular disciplines of science.
These errors result in an incomplete knowledge base, distorting the entire research process by narrowing the scope of reception of practical research tools. Digitization of literature, access to databases, and cataloging databases using keywords create an opportunity to avoid the errors mentioned above while dramatically accelerating the process of selecting a text database and reducing its cost (Czakon et al., 2019).
The main question is: *What is the taxonomy of network based on knowledge and ICT?* In addition to the main question, the following auxiliary questions were asked:

1) What typologies of network based on knowledge and ICT are proposed by various researchers in the literature on the subject?
3) What are the main problems in developing a typology of network based on knowledge and ICT?
5) What are the directions (trends) in developing network based on knowledge and ICT?
7) What are the theoretical and managerial implications?
In the database search process, three keywords were selected, namely:
1. knowledge-based network*
2. collaborative network*
3. ICT
Depending on the selected keywords, the following research sequence was defined in accordance with the suggested Boolean operators (advanced search): "*knowledge-based network*" OR "collaborative network*" AND ICT*" By the research functionalities of the databases, selected keywords were searched in "Subject" (including Title, Author Keywords, Abstract, Keyword Plus®) on WoS and in "Title, Author Keywords, Abstract" on Scopus. The author limited ourselves to journal articles, assuming that such narrowing improves the potential rigor and quality of the literature review. Because most academic journals are based in English, research has focused on English-language articles only. After specifying the language and type of papers, the scope of articles was limited to 6 areas in the Scopus database and 17 in the WoS database. Next, the "search within results" feature was employed to search for articles using the following keywords: "typology" and "taxonomy".
In addition, no chronological restrictions were applied. As a result, Scopus returned 107 articles, and WoS returned 81 articles, for a total of 188 documents. Table 1 summarizes the research strategy adopted to develop a systematic literature review. Search in Scopus and WoS was last accessed on June 4, 2023. This means that some publications from the last year (2023) were still under review or publication by their respective journals. Therefore, the number of publications is expected to increase until the end of the year.
In line with the classical systematic approach to the literature review, descriptive literature analysis usually includes the statistical distribution of articles over time, industries, research methods used, and geographic regions covered. However, given the purpose of this study, the adequacy of such additional analysis is limited. However, the wealth of identified, predominantly specific approaches and research proves that the analyzed issues are often addressed. However, in the analyzed set of articles, a small number of texts referring to different taxonomies of knowledge-based and ICT-based network models were identified, which confirms the previously mentioned research gap. For this reason, the "snowball" method was additionally used for the literature review—that is, to further expand the literature review on the subject by locating and examining some additional scientific sources that are not present in the selected database (Zhang & Banerji, 2017). The use of the ResearchRabbit tool supported the application of this method. ResearchRabbit is an innovative "citation-based literature mapping tool" available online, which aims to optimize the time of searching for references.
The author focuses on peer-reviewed scientific publications in this review because they are considered more credible than gray literature. In addition, due to time constraints, conducting a complete gray literature review was impossible. A review of the key available gray literature documents in English was conducted. However, it was decided to omit gray literature for the following reasons:
– It is not usually peer-reviewed, which means that it is not guaranteed to be reliable,
– It is usually hard to find because it is not published in traditional distribution channels,
– It is not updated as often as scientific literature, or
– It has low-quality level due to lack of reviews and quality control.
Despite these arguments, there are also situations where gray literature can be valuable, especially in areas where formally published work is limited or where recent results and debates are involved.
In addition to SLR, the taxonomy method (typological analysis, typological approach) was used. The purpose of developing a taxonomy is to systematize sets of objects or phenomena belonging to the scope of the relevant science. This description ranks the considered set of objects to develop, systematize, and specify the conceptual apparatus in a given scopeand characteristic for a particular science. The developed taxonomy is to perform both a theoretical function by indicating trends in the development of knowledge- and ICT-based network models, as well as a practical one, constituting a tool for further analysis.

Table 1. Summary of the results for the search string

The search phrase: „knowledge-based network*" OR „collaborative network*" AND ICT					
	Scopus 161	**Total sample size on Scopus**	**WoS 295**	**Total sample size on WoS**	**Total**
LIMITED TO:					
Language	English	155		285	
Document type	Articles, conference paper	120	Articles	123	
Subject Areas	Computer Sciences (75) Social Sciences (18) Business, Management and Accounting (19) Decision Sciences (37) Economics, Econometrics and Finance (5) Multidisciplinary (3)	107	Computer Science Artificial Intelligence (16) Computer Science Interdisciplinary Applications (14) Computer Science Information Systems (13) Computer Science Theory Methods (10) Environmental Studies (10) Business (8) Management (8) Telecommunications (8) International Relations (7) Environmental Sciences (6) Economics (5) Engineering Industrial (5) Engineering Multidisciplinary (4) Green Sustainable Science Technology (4) Automation Control Systems (2) Development Studies (2) Engineering Biomedical (2)	81	188
Search within results	*Typology or taxonomy*	14	*No filter*		
Total papers					188

Source: own work

RESULTS

In the next steps of the procedure, by the SLR criteria presented in Table 1, content analysis was performed.
The analysis of the content of the publication allowed to identify different types of networks of art and ICT from the widely cited literature. Table 2 presents a summary of selected types of networks based on knowledge and ICT. Fig. 2, in turn, shows the number of publications on the types of networks based on knowledge and ICT in 2003–2023, that is, over 20 years. The analysis of the number of publications in this period indicates specific dynamics. It is not an ever-growing trend. The most significant number of publications was recorded in 2008 and 2016 (Scopus) and 2008 and 2013 (WoS).

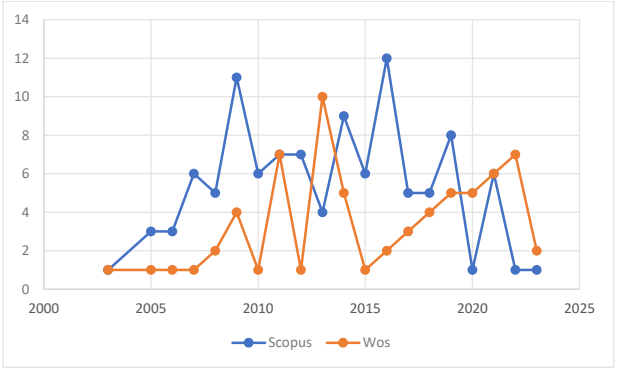


Figure 2. Publications on types of networks based on knowledge and ICT in 2003–2023.
Source: Own description based on Scopus and WoS.

Table 2. Summary of selected types of networks based on knowledge and ICT

References	A kind of network model based on knowledge and ICT
(Baldissera & Camarinha-Matos, 2018)	Elderly Care Ecosystem (ECE) framework and a Service Composition and Personalization Environment (SCoPE)
(Ma i in., 2022)	International R&D collaboration networks are investigated in the four major domains of CCMTs, namely, green energy (EGTD), green *ICT* (*ICT*), green transportation (TRANS), and green building (BUILD)
(Zhao i in., 2021)	The inclusive entrepreneurial ecosystem
(Tsou i in., 2019)	Business ecosystem: cooperation networks in the hospitality industry in Taiwan
(Santanna et al., 2014)	Collaborative-Driven SOA Providers Networks
(Opresnik i in., 2014)	Collaborative networks within the field of Product-Service (P-S)
(Adu-Kankam & Camarinha-Matos, 2023)	Collaborative virtual power plant ecosystem (CVPP-E) and a cognitive household digital twin (CHDT)
(Camarinha-Matos i in., 2023)	Research and Innovation Ecosystem
(Camarinha-Matos & Afsarmanesh, 2021)	Collaborative Networks 4.0
(Dos Santos i in., 2020)	Industry 4,0 Collaborative Networks

Source: Own description based on SLR.

The presented list shows selected examples of types of networks based on knowledge and ICT technology. Numerous authors (Camarinha-Matos & Afsarmanesh, 2021; Dos Santos et al., 2020; Opresnik et al., 2014) refer to collaborative or collaborative innovation networks—CoINs. These networks are an example of a distributed organizational structure that can be defined as self-organizing groups working to achieve a common goal, sharing ideas and knowledge. P. Gloor of the MIT Sloan Center for Collective Intelligence coined the term. Innovative collaborative networks consist of virtual teams that exchange information and knowledge to achieve a shared vision. The basis for the functioning of such networks is communication via the Internet and information technology (IT) (Gloor, 2006). Collaborative innovation networks are a type of collaborative innovation practice that uses online platforms such as email, chat, social networking, blogs, and wikis to promote communication and innovation within self-organizing virtual teams. In most cited publications, the authors describe this type of network as a social construct with high innovation potential, a type of open collaboration that helps organizations become more creative, productive, and efficient. Companies that use CoINs accelerate innovation, uncover hidden business opportunities, reduce costs, and increase synergies.

Collaborative networks manifest themselves in many forms, including virtual organizations, virtual enterprises, dynamic supply chains, professional virtual communities, virtual labs, etc. Currently, a large body of empirical knowledge related to collaborative networks has been accumulated, but according to many researchers (Camarinha-Matos & Afsarmanesh, 2021; Dos Santos et al., 2020), there is still a need to consolidate this knowledge and lay the foundations for a more sustainable development of the area. Collaborative networks are largely based on technological progress and the opportunities offered by current information and communication systems. The concept covering the essence of these networks most comprehensively is industry 4.0. The advent of the Industry 4.0 era imposes on network participants the need to prepare for functioning in the new economic reality while implying the development and implementation of new network business models. Numerous publications also mention the concept of a business ecosystem (Baldissera & Camarinha-Matos, 2018; Tsou et al., 2019; Zhao et al., 2021), most often understood here as a network of various organizations involved in providing a specific product or service, both in the form of competition as well as cooperation. According to this concept, each participant in the ecosystem influences and is influenced by others, which results in a constantly evolving relationship. If it wants to survive, each of its participants must be flexible and able to adapt to new conditions. The logic of the system is analogous to that of biosystems. This parallel was first used in 1993 by business strategist James Moore (Moore, 2002). The articles cited include research and innovation ecosystem (Adu-Kankam & Camarinha-Matos, 2023; Camarinha-Matos i in., 2023) and ecosystems operating in various industries (Baldissera & Camarinha-Matos, 2018).

Based on the analysis of the publication's content, an interpretation of the notion of networks based on knowledge and ICT can be formulated and their characteristics determined. Knowledge and ICT-based networks refer to the systems, infrastructure, and technologies that enable the exchange, storage, and dissemination of information and knowledge within organizations and across the Internet (Afsarmanesh et al., 2010; Dos Santos et al., 2020; Tavangarian, 2012). These networks play a crucial role in facilitating communication, collaboration, and access to information in various domains. Here are some key aspects related to knowledge and ICT-based networks (Hamer & Mays, 2020)(Table 3):

Table 3. Features and key aspects of networks based on knowledge and ICT

Characteristics	Key aspects
Information and Data Management	Data Storage and Retrieval Database Systems Data Security
Communication and Collaboration	Networks facilitate the exchange of messages, documents, and multimedia content through email servers, instant messaging platforms, and collaborative tools. Networks enable real-time audio and video communication, allowing individuals or groups to interact remotely and collaborate effectively. Virtual Collaboration Platforms: Networks support the use of collaborative software tools and platforms that enable teams to work together, share knowledge, and coordinate activities irrespective of their physical location
Internet and Web Technologies	Internet Connectivity Web-based Applications
Knowledge Management Systems	Networks support the creation of internal knowledge-sharing platforms (intranets) and external collaboration platforms (extranets) to enhance information flow and knowledge exchange within organizations or with external partners. Networks enable the deployment and management of CMS platforms, allowing organizations to store, organize, and publish digital content efficiently. Networks facilitate the creation and maintenance of centralized knowledge repositories, databases, or wikis, which store and provide access to explicit knowledge assets within organizations
Emerging Technologies	Internet of Things (IoT): Networks play a vital role in connecting and managing IoT devices, enabling the collection, analysis, and sharing of data from various sensors and smart devices. Artificial Intelligence (AI) and Machine Learning (ML): Networks support the training and deployment of AI and ML models, which can process and analyze large amounts of data, extract insights, and automate knowledge-based tasks. Blockchain: Networks based on blockchain technology enable secure and decentralized sharing and verification of information, with applications in areas such as supply chain management, digital identity, and intellectual property rights.

Source: Own description based on SLR.

These aspects demonstrate the diverse range of knowledge and ICT-based networks and their impact on information exchange, collaboration, and knowledge management in organizations and society at large.

DISCUSION

The presented results provide valuable insights into the landscape of networks based on knowledge and ICT, shedding light on various types of networks and their characteristics. This discussion aims to delve further into the implications and significance of these findings and contextualize the identified network models within the broader landscape of collaborative and innovative networks.

The analysis of the number of publications on types of networks based on knowledge and ICT over 20 years reveals distinct dynamics. While there was a substantial peak in publications in 2008 and 2016, according to Scopus, and in 2008 and 2013, according to WoS, the trend is not characterized by a continuous increase. This variation could be attributed to shifts in research focus, technological advancements, and new research paradigms. Further investigation could explore the factors contributing to these fluctuating trends.

The proliferation of collaborative networks rooted in knowledge and ICT has catalyzed transformative shifts across diverse sectors (Camarinha-Matos & Afsarmanesh, 2021; Dos Santos et al., 2020). The Elderly Care Ecosystem framework and the Service Composition and Personalization Environment, innovated by Baldissera & Camarinha-Matos (2018) stand as exemplars of harnessing technology to cater to the needs of aging populations. This convergence of knowledge and ICT has paved the path for inventive strategies, elevating healthcare services and the quality of life for the elderly.

A significant number of authors' (Adu-Kankam & Camari (2023); Camarinha-Matos & Afsarmanesh, 2021; Dos Santos et al., 2020; Opresnik et al., 2014) address the issue of innovation networks (CoINs). The findings suggest that these networks can drive innovation, reveal untapped business opportunities, and yield synergies, thereby contributing to organizational growth and development.

Moreover, the exploration of International Research and Development (R&D) collaboration networks spanning green energy, ICT, transportation, and green building by Zhao et al. (2021) underscores collaborative networks' pivotal role in propelling sustainability initiatives. The fusion of knowledge and ICT fuels cross-domain cooperation, yielding holistic solutions for pressing global challenges like climate change mitigation.

The inclusive entrepreneurial ecosystem investigated by Tsou et al. (2019) accentuates the importance of knowledge-sharing and technological resources in nurturing innovation within business ecosystems. This research highlights how collaborative

networks can cultivate an atmosphere conducive to entrepreneurial expansion, mainly through synergizing knowledge and ICT. The study by Santanna et al. (2014) delves into cooperation networks in the hospitality sector, emphasizing how collaboration-driven Service-Oriented Architecture (SOA) provider networks can spark innovation. Combining knowledge and ICT catalyzes inventive solutions and enhanced service offerings within a competitive landscape.

The Industry 4.0 paradigm has ushered in Industry 4.0 Collaborative Networks (Dos Santos et al., 2020), further accentuating advanced technologies' transformative potential. The fusion of knowledge and ICT in this context heralds a new era of interconnectedness, automation, and efficiency in manufacturing and industrial processes.

The emergent Collaborative Networks 4.0 and Research and Innovation Ecosystem models (Camarinha-Matos & Afsarmanesh, 2021; Camarinha-Matos et al., 2023) epitomize the ongoing evolution of collaborative networks. These models underscore the necessity for dynamic adaptation to technological advancements, with knowledge and ICT propelling the continual evolution of networked organizations.

The insights drawn from these diverse network models underscore the intertwined nature of knowledge and ICT in shaping collaborative ecosystems. The discussed models collectively reinforce that successful collaboration in today's interconnected world is intricately linked to the seamless integration of knowledge and ICT. These networks facilitate innovation, sustainability, and entrepreneurship by harnessing the power of shared knowledge and cutting-edge technological capabilities.

In conclusion, the diverse range of network models presented in this SLR underscores the multifaceted impacts of collaborative networks based on knowledge and ICT. From addressing societal challenges to fostering business innovation, these models illuminate the transformative potential of synergizing knowledge and technology within collaborative ecosystems.

Industry 4.0 emerges as a central theme in the knowledge and ICT-based networks landscape. The advent of the Industry 4.0 era underscores network participants' need to adapt to the evolving economic landscape by developing new network business models. This observation reflects the transformative power of technological progress, with Industry 4.0 serving as a comprehensive concept encapsulating the essence of these networks.

Moreover, the business ecosystem concept is highlighted as an essential paradigm in network dynamics. This ecosystem comprises diverse organizations engaged in delivering specific products or services, both through competition and collaboration. The mutual influence and evolution of ecosystem participants emphasize the need for adaptability in changing conditions akin to the dynamics observed in biosystems. This notion echoes the idea of interdependence and co-evolution among ecosystem members, as introduced by James Moore's business ecosystem concept.

The research conclusions underline the diversity and importance of knowledge- and ICT-based networks. From collaborative innovation networks to Industry 4.0 transformations and business ecosystems, these networking models represent dynamic approaches to driving innovation, knowledge sharing, and collaboration. Key aspects of these networks highlight their role in supporting information flow, communication, and knowledge management. As technological progress continues, these networks will evolve, catalyzing innovation and stimulating organizational and societal development. However, the observed fluctuations in scientific publications over time suggest the need for ongoing research to understand the underlying trends and factors influencing the evolution of ICT-based knowledge and networks.

TOWARDS A TAXONOMY OF KNOWLEDGE- AND ICT-BASED NETWORKS

Considering the adopted criteria for SLR (Table 1), the content analysis allowed for identifying the main variables/elements of networks based on knowledge and ICT, as well as the criteria for division and, consequently, the taxonomy of the analyzed networks. The literature review on the subject shows that the category of networks based on knowledge and ICT technology is internally differentiated. We can talk here about the network models created due to the virtualization process and models made as a result of the exchange and flow of intangible assets. The taxonomy of knowledge- and ICT-based network models is presented in Fig. 3.

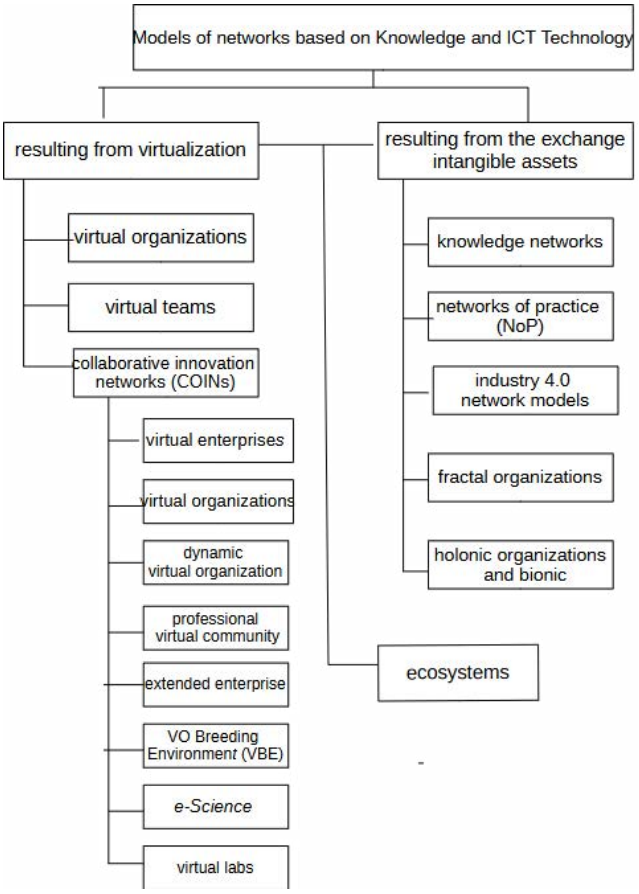


Figure 3. Taxonomy of networks based on knowledge and ICT
Source: Own work

A specific type of organization based on knowledge management and ICT technologies is created due to the virtualization process. Virtualization is a harbinger of a new direction in the sciences of organization and management, having a theoretical and practical dimension. It is a process through which enterprises of all sizes can take a form that will allow them to become fully competitive in an ever-changing global market. The adaptation process consists of speedy learning, resulting in the organization adapting to the new environmental requirements. This process is done by changing the organizational structure and profile of production or services. These changes are possible thanks to the practical use of knowledge management. Acquisition of knowledge takes place not only thanks to having appropriate staff but also thanks to IT. In this way, the organization can learn quickly, taking advantage of the opportunities offered by the Internet, especially e-learning. The use of ICT, especially computer networks such as the Internet, allowed the acquisition of theoretical knowledge from diverse sources.

The second category of organizations based on knowledge management are models created due to the exchange and flow of intangible assets. The idea of value exchange, the author of which is V. Allee (Allee, 2000), is based on the assumption that network participants and stakeholders participate in the value network by transforming the value of their influence on other parties into an increase in their assets. According to the author mentioned above, there are two types of value flows between the parties: (1) receipts, or values received, and (2) expenses, or values delivered. As part of receipts and expenses, there is a traditional exchange of tangible and intangible assets. In the distinguished network models based on knowledge and ICT technology, the exchange of intangible assets, including strategic information, process knowledge, technical know-how, cooperation design, joint planning of activities, and development policy, is significant. Intangible benefits are advantages or favors that can be magnified from one person or group to another person or group. Creating an organization's value depends on intangible resources (even more than tangible ones). Combining employees' skills, knowledge, and experience increases

the efficiency with which an organization uses intangible resources to create value. In these networks, the dominant help is knowledge, perceived as an organization's strategic, intangible resource, and intra- and inter-organizational relations based on the exchange and flow of resources (including information and knowledge).

The networks created as a result of the exchange processes and the flow of intangible assets are, therefore, a nexus of relationships that generate value through dynamic, complex exchanges between two (or more) individuals, groups, or organizations. In addition to exchanging goods, services, and income, people exchange knowledge and other intangible values such as favors and benefits. The exchange of knowledge and other intangible assets is not only an activity that supports the business model but also part of this model—perceiving the enterprise as a value network results in a better understanding of the business model than perceiving the enterprise as a value chain.

A separate category of networks, combining the two types discussed earlier, is ecosystems. An ecosystem is treated as a community of related entities, defined by its place in the network and connections, as well as from the perspective of the analysis of the ecosystem's structure, so when it is treated as a configuration of activities related to the value proposition. A business ecosystem refers to a network of organizations, individuals, and various other entities that interact and collaborate within a particular industry or market. It involves a complex web of relationships, dependencies, and interactions among these entities, all of which contribute to the functioning and growth of the overall ecosystem. In a business ecosystem, different entities such as suppliers, customers, competitors, government agencies, research institutions, and service providers are interconnected and mutually dependent. They often rely on each other's products, services, expertise, or resources to create value and achieve their respective goals. Business ecosystems can be found in various industries, such as technology, healthcare, finance, and manufacturing (Adu-Kankam & Camarinha-Matos, 2023; Camarinha-Matos et al., 2023; Moore, 2002). Examples of well-known business ecosystems include the Apple ecosystem (comprising hardware, software, developers, and app users), the Amazon ecosystem (including sellers, buyers, third-party developers, and logistics partners), and the automotive industry ecosystem (involving car manufacturers, suppliers, dealerships, and repair service providers).

An overview of selected types of knowledge-based and ICT-based networks, along with a brief description, is presented in Table 4.

Table 4. Overview of selected types of knowledge- and ICT-based networks

Virtual organizations	**Their essence is the ability to use the economic, intellectual, and organizational potential found in various places around the world in a way that does not fit into the traditional framework and patterns of business activity. This concept means resignation from rigid, clearly defined organizational boundaries, a strong focus on customer needs, and the ability to cooperate in teams whose members are people with clearly defined skills. In recent years, the topic of virtual organizations has become part of a new discipline: collaborative network) (Camarinha-Matos, 2009; Camarinha-Matos & Afsarmanesh, 2021).**
Virtual teams	Have a clearly defined goal that connects all team members and the competencies needed to achieve this goal. Team members work together to achieve a goal; the roles of team members and the rules of cooperation are defined. The virtual team is characterized by the need for more than one location, the use of electronic communication for everyday collaboration, the different work styles of virtual team members, and the lack of direct contact between virtual team members. Virtual teams would not be possible without appropriate technology—they function in a virtual space (a platform that combines all types of communication). Members of virtual teams should have excellent communication skills, high emotional intelligence, and the ability to work independently.
Collaborative Innovation Networks (CoINs)	This kind of network is an example of a dispersed organizational structure, defined as self-organizing groups working to achieve a common goal, sharing ideas and knowledge. The term was coined by Peter Gloor (Gloor, 2006) of the MIT Sloan Center for Collective Intelligence. They consist of virtual teams exchanging information and knowledge to realize a shared vision. Such a network is a social construct with a high innovation potential. CoIN is an open collaboration that helps organizations become more creative, productive, and efficient. Collaborative networks come in many different forms, including virtual organizations, virtual enterprises, dynamic supply chains, professional virtual communities, virtual labs, etc. (Camarinha-Matos & Afsarmanesh, 2021).
Network models emerging as part of the Industry 4.0 concept	The concept of Industry 4.0 requires transforming traditional and, even today, innovative business models. Changes related to, for example, the development of the concept of the Internet of Things, virtualization of services, the use of automatic identification techniques, the use of electronic data exchange, the use of artificial intelligence methods, and finally the progressive robotization of manufacturing processes are reflected in the evolution of network business models. The discussion in the literature on network business models allows for the identification of five general patterns (Dos Santos et al., 2020): (1) separation of business areas, (2) "long tail," (3) multilateral platforms, (4) FREE concept, and (5) open business models.
Knowledge networks	Are informal knowledge exchange systems within a specific domain of knowledge? These are not only intra- but also inter-organizational networks, connecting employees representing various specialties and disciplines of knowledge to achieve an individual goal, such as advice or support. They emerge in organizations and institutions, as well as between them, as a result of dynamic interactions of the individuals that make them up. New networks arise in the context (and as a result) of the emergence of new phenomena and new knowledge.

Communities of Practice (CoPs)	CoPs refer to groups of individuals who come together to share knowledge, expertise, experiences, and insights related to a specific domain or field of interest. These communities are formed to foster learning, collaboration, and the exchange of information among people who share common professional interests or challenges. CoPs can be found in various settings, including professional organizations, academic institutions, businesses, online platforms, and more. They can help individuals stay up-to-date with the latest developments in their field, gain insights from diverse perspectives and overcome challenges more effectively through collective expertise.
Network of practice (NoP)	A concept coined by J. Seely Brown and P. Duguid. (Brown & Duguid, 2000). This concept refers to a set of informal social networks that facilitate the exchange of information between people with practice goals. Thus, the ground that connects people in their networks is determined by the practice that implies the actions of individuals and groups when conducting their work, for example, the practice of software engineers, journalists, educators, etc. Practice networks thus include various practices, also using electronic practice networks (often called virtual or electronic communities).
Fractal organizations	An integrating approach; therefore, the multidimensionality of this issue comes to the fore. H. J. Warnecke understands the fractal as an independently operating unit of the enterprise whose goals and performance can be clearly described.
Holonic and bionic organizations	The essential element of the holonic organization is the holon, that is, an intelligent, autonomous, and cooperative block of the production system responsible for the transformation, transport, storage, and validation of information and physical objects accompanying the production process. Individual functions of the holonic organization are automated thanks to the use of, for example, robots, manipulators, automatic warehouses, and testers. Information technologies enable the implementation of process control functions, for example, accepting customer orders, purchasing materials, balancing production capacity, modeling products, or controlling schedules and production processes (Balasubramanian et al., 2000) Bionic organizations, in turn, are production systems that dynamically adapt to changes in the internal and external environment, which have such properties thanks to mapping the mechanism of the behavior of living organisms. They are characterized by, for example, self-organization thanks to the construction of multi-level networks that map production areas, self-replication, self-recognition, self-learning, adaptation to product and production changes, and self-growth.

Source: Own work.

The complexity and difficulty of the undertaken approach indicate the need to determine the development directions of these network models and the directions of further research. Several issues are significant (Barczak, 2020).

First, in the coming years, network models will be rapidly developed based on knowledge and ICT technology. These models will strengthen their position both in the local and global markets. The growing trend in the use of IT will increase the pace of learning, taking advantage of the opportunities offered by the Internet and the emergence of 5G technology. Another significant trend is the growing use of deep learning techniques such as neural networks and the evolution of conversational AI for human-like interactions. From the point of view of the indicated threats, it is also essential to develop secure and privacy-protecting methods for network data.

Second, the vast majority of contemporary networks can be considered as complex networks. Researchers' attention is currently focused on random networks. The interest of researchers in these networks is not only because they are interested in complex networks of crucial importance today—the Internet and telecommunications networks. The most important reason for the interest in complex networks is that their topological properties and structure differ from the properties and structure of already described and relatively well-studied deterministic networks. It is necessary to take a new look at the analysis of complex networks and to develop new research methods. It seems advisable to develop research in the field of applying methods from other areas of science, including in particular network analysis. Analytical possibilities offered by IT tools supporting this method allow for efficient research of very complex structures of connections (including up to several thousand entities).

Third, an exciting and specific area of research is the phenomenon of scale-free networks (Barabási, 2009). It is essential to skillfully use the knowledge of these phenomena to manage organizational networks effectively. Of particular importance are discoveries in network topology (small-world networks, scale-free networks) whose features have been discovered in significantly different systems, including organizational networks. Network topology discoveries have changed considerably how networks are viewed and analyzed. The properties of scale-free networks, as well as the occurrence of the so-called Therefore, Small World effect, should be taken into account in network research and when assessing its effects (network design, predicting scenarios of events occurring in the network at the IT, business, and social levels).

CONCLUSIONS

In conclusion, it can be stated that the discussed category of networks is a system of partnership contacts and alliances between entities to increase resources and or implement their offer. The functioning of these networks in the context of value creation comes down primarily to strengthening the position by creating, developing, and maintaining relationships—conditioning the

product and delivery of value—with other network participants. The starting point is the effectiveness of functioning and the ability to use ICT technology and to create and share knowledge.

There is no doubt that new technologies are an essential determinant of the development of organizational networks. They allow organizations to connect, exchange information and knowledge, and collaborate in new ways. Some of the factors that I believe are important in this process include:

1. Tools to improve communication and collaboration.
2. Online platforms—to build networks of customers, partners, and employees.
4. Big data and analytics—support and improve decision-making processes and enable a better understanding of network relationships.
6. Cloud computing—enables access to resources and information and sharing them in real-time, fostering cooperation and innovation.
8. Internet of Things—enables connecting and exchange of data between devices, systems, and people, creating new opportunities for cooperation and innovation.
10. Artificial intelligence—provides organizations with new tools for automating and optimizing processes, leading to new networks and strengthening the existing ones.

The examples cited show that new technologies are changing the way organizations interact and collaborate and drive the development of more complex, interconnected, and dynamic organizational networks. New technologies such as digital platforms and social media are breaking down geographical, cultural, and organizational barriers, leading to more diverse and inclusive networks.

The presented considerations allow us to formulate the following theoretical implications:

– the developed typology can help in obtaining an orderly and synthetic image of the tested network,
– allows for further analyses and comparisons, searching for the dependence of a typological variable on other variables included in the research, and for describing and deriving evaluative and normative statements,
– the complexity, indefiniteness, and volatility of the relationship between the organization's intangible resources make it difficult to assess the effects of networks based on knowledge and ICT,
– the discussed network models allow for effective management of intangible resources and also (using network analysis) for intervention where this efficiency is threatened or low, and
– by examining the discussed models with the use of network analysis, it is possible to (1) identify the most prominent (central) intangible assets in the organization, as well as those peripheral, located on the outskirts of the network, and (2) study the dynamics of the network.

The development of knowledge-based and ICT-based network taxonomies has important managerial implications that can help them better understand and exploit the potential of these networks. It is a possibility for:

– adapting your business strategies to a specific category of knowledge-based and ICT-based networks,
– identifying areas where they can introduce innovations,
– identifying potential partners and collaborators in specific areas,
– having knowledge management in the organization—they can focus on the use of appropriate tools and platforms that will foster the exchange of knowledge and information within the company and with external partners, and
– using both internal and external communication.

The practical usefulness of the proposal contained in the study is related to the possibility of using the proposed concept to evaluate various types of network models, which will enable the formulation of diagnostic findings and conducting comparative and dynamic research in the field of analysis and evaluation of knowledge-based and ICT-based network models.

The main limitations of the conducted research are as follows:

– SLR results are based on existing scientific publications, which means that data sources may be limited to what has been published. New and innovative concepts that have not yet found their way into the scientific literature may be missed,
– Various terms and definitions may be used interchangeably or ambiguously in the literature. This can lead to difficulty in creating a coherent taxonomy or identifying appropriate categories,
– Literature searches may be susceptible to biased results from low-quality publications, misinformation, or the tendency to publish only positive results,
– SLR results may be limited to what has been published and may not necessarily reflect reality in practice. Lack of field verification may result in limited usefulness of the developed taxonomy in practical applications,
– Little timeliness—new publications may introduce new concepts and categories that have not been included in the taxonomy, and

– SLR results may not contain enough contextual information, leading to difficulties understanding the complete picture of the relationship between different categories.

Given the limited research in this field, the proposed framework for the taxonomy of knowledge-based and ICT-based network models is a preliminary suggestion. While the typology serves primary theoretical purposes, it can also provide a basis for developing guidelines for social and economic practices. This framework can benefit researchers and practitioners studying knowledge-based networks and ICT use in organizational networks.

The indicated directions of research determine the possibilities of improving the proposed concept. A deeper analysis of knowledge- and ICT-based network models and improvement of their taxonomy is recommended, as well as empirical verification of the proposed concept.

To some extent, the approach proposed in the study fills the research gap related to the need for more studies in this field, although this issue still offers inspiring research potential.

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