**Chapter N**

**Conceptualizing and Defining Digital Innovation**

**Ecosystems. Systematic Literature Review**

**Abstract.** Rapid development of digital technologies creates digital ecosystems that penetrate into everyday life of the society. Digital ecosystem is a relatively new phenomenon and has multiple connotations and dimensions in the scientific literature, but it is univocally recognized as a context of technological execution of both innovation and business ecosystems. A digital innovation ecosystems (DIEs) give new opportunities but at the same time pose new challenges related to interaction between citizens, communities, organizations and the territories in the rapidly changing environment. The concept of DIE is only partially debated in the scientific literature, so the main objective of this research is to provide a full- fledged definition of the term DIE and the core components of the studied phenomenon. In order to reach the goal an approach based on a broad systematic literature review (SRL) of scholarly studies is adopted. SRL on the definitions and dimensions of DIEs provides evidence on the nature and components of this rising trend, allowing an in-depth understanding of the dynamics in this domain. The main results of the research are the aggregation and analysis of the various definitions and components of the DIEs, their systematization and formulation of comprehensive and shared ones; identification of internal and external context DIE variables and levels of the DIEs allocation.

**Keywords.** Digital innovation ecosystems, digital innovation, systematic literature review

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**1.1 Introduction**

Digital technologies are the key elements that are shaping everyday life of the society nowadays. The digitalization is becoming an important topic of discourse both in scientific literature and at the governmental national and supranational levels. Thus, the United Nations digital strategy 2022-2025 has the aim to create a world in which digital is an empowering force for people and planet in three directions of change – structural transformation, leaving no one behind, and building resilience (UNDP, 2022). One of the European Commission’s (EC) main priorities for the 2019-2024 period is “A Europe fit for the digital age” - the European Union’s (EU) digital strategy will empower people with a new generation of technologies. The EU’s digital strategy aims to make digital transformation work for people and businesses. The main three pillars of the European approach are 1) technology that works for the people; 2) a fair and competitive digital economy and 3) an open, democratic and sustainable society (European Union, 2020).

The digital age is characterized by technology, which increases the speed and

breadth of knowledge turnover within the economy and society (Shepherd, 2004). Indeed the digital transformation of the last decades has strongly affected markets, customers, firms (Verhoef P.C. et al. 2021) and diffusion of innovation (Y. Yoo et al. 2010). As a result of these changes, the limits and the barriers among the economic actors has fell down, new products and services are introduced and there are more efficient ways to do business (Schwertner K., 2017). In this new dynamic context, the innovations are increasingly the result of a network that could present the form of an “ecosystem” (Kolloch M. & Dellermann D., 2018) and less and less the result of the action of a single entrepreneur (Hagedoorn 1996); all this poses new challenges to the actors involved in innovation processes (Adner R., Kapoor R., 2010). The concept of “Ecosystem” is widely studied in the literature (Adner R. 2006; Iansiti M & Levien R. 2004; Christensen C.M., Rosenbloom R.S. 1995; Kolloch M. & Dellermann D., 2018; Basole R.C. 2009) as well as the concept of “Innovation systems” (Freeman R. et al. 1987; Breschi and Malerba, 1997) but the “Innovation ecosystems” has become popular during the last years and the debate around the ambiguously of the term has been increasing in time (Granstrand O. & Holgersson M., 2020). A synthetic way to describe this phenomenon is reported in Dodgson M. et al. 2014, where the “Innovation ecosystems” are defined as a range of different way to define value-creating interactions among different actors; in fact, it can represent a new way to conceive the value creation linked to the concept of innovation (Adner R., Kapoor R., 2010). Digital Innovation Ecosystems (DIEs) being an inevitable part of the innovation context lack a coherent theory to

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synthesize the diverse opinions, experience-based insights, and research findings about DIEs (Wang, 2020). So the main goal of this research is to gather the evidence in the scientific literature on the definitions and core components of the DIEs with their further conceptualization.

The paper is organized as follows: section 1.2 step-by-step illustrates the research

method applied to the study and introduces the research questions; in section 1.3, the results of the study are represented; section 1.4 provides conclusion remarks on the study.

**1.2 Methodology**

A systematic literature review (SRL) is a key tool of an evidence-based approach that enables a researcher to analyze and structure the knowledge existing in the scientific literature for its further practical and scientific use (Tranfield et al., 2003). Following the format of previous SLRs (Durach et al., 2017, Savastano et al. 2019) a six-step review process was carried out in this research.

(1) Stage one of our research involves *definition of the research questions and keywords*. The study has the aim to gather the evidence in the scientific literature on the definitions and core components of the DIEs. The DIE phenomenon has entered the international scientific discourse more than a decade ago, but its characteristics are still illegible and depend on the context of the research. Therefore, the authors of this study found it interesting to explore the plethora of the scientific literature where the DIEs were discussed. In order to do so the keyword combination "digital innovation ecosystem\*" was chosen; a wildcard \* was applied to the keyword combination in order to embrace the cases when the keyword combination was used in plural.

Taking into account all of the above the main research question (RQ) of the paper is:

**RQ:** What is the “state of art” of the academic literature regarding the DIEs? The nature of the research approach and the aim of this study imply the deepening of the existing knowledge on the DIEs, so the following sub research questions (SRQ) should be answered in the study:

**SRQ1:** What are the system levels of the DIEs discussion?

**SRQ2:** What definitions of DIEs are presented in the scientific literature? **SRQ3:** What are the main components and their interplay in the DIEs? **SRQ4:** What are the common dimensions of the DIEs discussed in the scientific literature?

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(2) The next step of the study is *the determination of the required characteristics of the studies and the inclusion criteria* in order to focus on relevant and rigorous literature sources only:

The authors agreed to study the peer-reviewed articles and

conference papers written in English, with no limitation on the year of publication, it this way the whole amount of literature on the topic could be retrieved; for the same reason no geographical limitations were applied;

To ensure academic quality the Web Of Science (WOS) and Scopus online databases were used in the research, because these databases guarantee peer-reviewing of the articles; the study was corroborated by supplementary materials identified in Google Scholar – so in case when the articles where extracted form Google Scholar database the authors additionally checked whether the study was subject to a peer review;

The central theme of the studied articles was chosen intentionally in order to not limit the future results of the research and to study the discussion on the DIEs in its vast variety.

By following these criteria, we included all the papers relevant to the purpose of the study and ensured there quality.

The summary of the inclusion criteria and its characteristics is presented in the Table 1.

Type of inclusion criteria Characteristic of inclusion criteria

Document type Articles and research papers Time period Not specified Language English

Geography Worldwide

Databases Scopus, WOS, Google Scholar

Table 1. Inclusion criteria and its characteristics

(3) Stage three involves the primary *retrieving a sample of potentially relevant literature* according to the keywords and inclusion criteria discussed using the default search field TITLE-ABS-KEY in Scopus, Topic field in WOS and the above-mentioned keywords combination in the search box of Google Scholar.

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(4)On the fourth stage of the study the selection of the pertinent literature was conducted. The Preferred Reporting Items for Systematic Review (PRISMA 2020) checklist was adopted for the stages of identification, screening, and inclusion of papers in this review (Page et al., 2021). PRISMA represents the widely accepted methodological standard for performing systematic literature reviews in business and management studies and related fields (Ambad, 2022; Sikandar and Kohar, 2021). Figure

1 represents the PRISMA flow diagram to report the different stages of

literature selection.

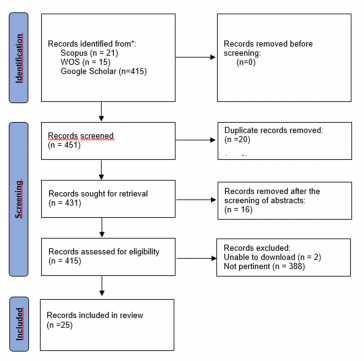


Figure 1. Articles’ selection stages based on PRISMA 2020 flow diagram

(5) The next step of the systematic review process includes *synthesizing of the literature* by applying “coding scheme to extract pertinent information from the literature and synthesizing studies by summarizing, integrating, or cumulating the different ﬁndings across the primary studies” (Durach et al.2017). The coding categories were predefined and corresponded to the aim of the study and its RQ and SRQs.

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(6) Finally, the results of the study were analyzed and reported providing a descriptive overview of studied literature and discussing thematic ﬁndings answering the RQ and SRQs discussed above. The findings of the review process are presented in the next paragraph.

**1.3 Results and discussion**

***1.3.1 Characteristics of the studied literature***

As it was already mentioned in the paragraph above, we selected 25 articles from 451 found in 3 databases for our research. Figure 2 shows the distribution of studied literature by years. The first mention of DIE dates back to 2011, but research on the topic has been growing since 2018, peaking in 2020. Such a distribution of the literature may indicate that the DIE phenomenon is just beginning to enter the scientific discourse even though the studied literature shows an in-depth research of this topic.

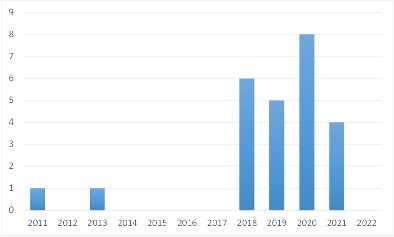


Figure 2. Distribution of the articles by years

Figure 3 shows the distribution of studies by country. As can be seen from the graph, USA is the leader in DIE research and Brazil, Germany and UK are in second place. Other EU countries represented in the scientific literature are Austria, Finland, France, Italy, Latvia, Poland, Slovenia, Spain and Sweden. In total, the countries of the EU account for approximately half of the studies.

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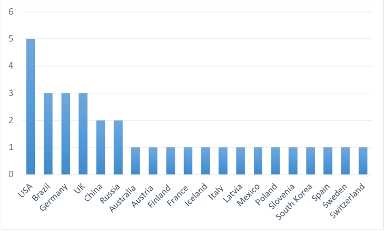


Figure 3. Distribution of the articles by country

The distribution of articles in the table 2 is heterogeneous; the articles are almost equally distributed between the sources and their types – journal publications and conference proceedings. The authors believe this may indicate the gradual settlement of the DIE phenomenon into scientific discourse of the recent years.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Journal** | **‘11** | **‘12** | **‘13** | **‘14** | **‘15** | **‘16** | **‘17** | **‘18** | **‘19** | **‘20** | **‘21** | **‘22** | **Tot.** | **%** |
| Advances in Intelligent Systems and Computing |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| IEEE Transactions on Engineering Management |  |  |  |  |  |  |  |  |  |  | 1 |  | 1 | 4 |
| Intereconomics |  |  |  |  |  |  |  |  | 1 |  |  |  | 1 | 4 |
| International Journal for Innovation Education and Research |  |  |  |  |  |  |  | 1 |  |  |  |  | 1 | 4 |
| International Journal of Information Management |  |  |  |  |  |  |  |  | 1 |  |  |  | 1 | 4 |
| Journal of Cleaner Production |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| Journal of Electronics and Information Science |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| Journal of Strategic Information Systems |  |  |  |  |  |  |  | 1 |  |  |  |  | 1 | 4 |
| MIS Quarterly: Management Information Systems |  |  |  |  |  |  |  |  |  |  | 1 |  | 1 | 4 |
| Project Management Journal |  |  |  |  |  |  |  |  | 1 |  |  |  | 1 | 4 |
| Research Policy |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| Sensors |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| Studies of Transition States and Societies |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| Technological Forecasting and Social Change |  |  |  |  |  |  |  | 1 |  |  |  |  | 1 | 4 |
| Technology Analysis & Strategic Management |  |  |  |  |  |  |  |  | 1 |  |  |  | 1 | 4 |
| **Conference proceedings** | **‘11** | **‘12** | **‘13** | **‘14** | **‘15** | **‘16** | **‘17** | **‘18** | **‘19** | **‘20** | **‘21** | **‘22** |  | **%** |
| 22nd Pacific Asia Conference on Information Systems |  |  |  |  |  |  |  | 1 |  |  |  |  | 1 | 4 |
| 27th European Conference on Information Systems |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| 31st International Business Information Management Association Conference |  |  |  |  |  |  |  | 1 |  |  |  |  | 1 | 4 |
| 40th R&D Management Conference “R&Designing Innovation:  Transformational Challenges for Organizations and Society” |  |  |  |  |  |  |  | 1 |  |  |  |  | 1 | 4 |
| 8th International Conference on P2P, Parallel, Grid, Cloud and Internet  Computing |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 | 4 |
| Hawaii International Conference on System Sciences (HICSS) |  |  |  |  |  |  |  |  |  |  | 1 |  | 1 | 4 |
| International Congress and Conferences on Computational Design and  Engineering |  |  |  |  |  |  |  |  | 1 |  |  |  | 1 | 4 |
| Portland International Center for Management of Engineering and Technology | 1 |  |  |  |  |  |  |  |  |  |  |  | 1 | 4 |
| Russian Conference on Digital Economy and Knowledge Management |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 | 4 |
| Working Conference on Virtual Enterprises |  |  |  |  |  |  |  |  |  |  | 1 |  | 1 | 4 |
| **Total** | **1** |  | **1** |  |  |  |  | **6** | **5** | **8** | **4** |  | **25** | **100** |

Table 2. Distribution of selected articles by journals and publication date

Table 3 represents the most used keywords in the studied literature ranked from 1 to 6 given that other collected keywords has the frequency 1, that is explained by the limited range of the studied literature. In addition to the keywords used to retrieve the literature, the most frequently used keywords are predictably connected to the specific elements of the digital innovation domain. However, the sample also included keywords related to the stakeholders of the DIE – startups and innovation community which we will discuss below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Keyword** | **Frequency** | **%** | **Rank** |
| innovation system | 8 | 9,36 | 1 |
| ecosystem | 6 | 7,02 | 2 |
| digital innovation | 5 | 5,85 | 3 |
| digitalization | 4 | 4,68 | 4 |
| Industry 4.0 | 4 | 4,68 | 4 |
| digital innovation ecosystem | 3 | 3,51 | 5 |
| digital transformation | 3 | 3,51 | 5 |
| ecology | 3 | 3,51 | 5 |
| startups | 3 | 3,51 | 5 |
| digital ecosystem | 2 | 2,34 | 6 |
| innovation community | 2 | 2,34 | 6 |
| open innovation | 2 | 2,34 | 6 |
| technology | 2 | 2,34 | 6 |

Table 3. Distribution of the keywords by frequency

***1.3.2 Definitions of the DIEs***

The literature body proposes several DIE definitions presented in the table

4. According to the evidence gathered, DIE could be defined as a complex innovation ecosystem of sociotechnical nature aimed at creating new products and services using digital technologies in order to create value; the scholars stress the presence of technological (digital) and social (physical) mutually interdependent components; the parts of the DIE constantly co- evolve learning how to interact effectively.

**Paper Definition of DIE**

Kolloch and Dellermann (2016) an innovation ecosystem as a social technological system (actor network) consisting of two inseparable parts: a social system (human actor network) and a technological system

(non-human actor network)

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Suseno et al. (2018) DIE models the interactions and relationships between organisations and stakeholders, in creating new products and services using digital technologies in order to create value

Wang (2018) a special type of sociotechnical system

a complex arrangement of technologies, methodologies, concepts, business application areas, organizations, and institutional contexts; a network of heterogeneous social and technical elements, which co-evolve over time

Beltagui et al. (2020) DIEs account for industry-spanning co-operative and competitive dynamics among firms related to innovations that combine physical and digital elements

Cvar et al. (2020) a complex system of various actors having different roles, interacting in mutual interdependence, constantly learning how to interact effectively

Wang, (2020) a special type of sociotechnical systems, a dynamic collective of interdependent actors and the resources they draw on to innovate with digital technology

Wang et al., (2021) a loosely coupled set of autonomous actors (people and organizations who interact without hierarchical fiat) involved in the development and implementation of innovations enabled by digital technologies

Table 4. DIE definitions in the literature

***1.3.4 Characteristics of the DIEs***

In order to categorize the studies under investigation the system level approach by Vanhamaki, et al. (2019) was applied; this research introduced the system level approach to circular economy describes the actors on macro, meso, and micro levels. The authors of the study brought this model to the research on DIE dividing the studied literature by system levels the DIE was applied to. Some of the research studied the universal nature of DIE applicable in all the levels, so we introduced the fourth group named “Meta level”. The results of the distribution are presented in the table 5.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | **System level** | **Actors** | **Papers** |
| **Meta level** | Vasin et al. (2018); Wang, (2018); | **Macro level** | Supranational organisations, Nations, cities, regions | Misseri (2013); Pistorio et al. (2018); Whyte (2019); Baumane-Vītoliņa and Dudek (2020); Cvar et al. (2020);  Filatova et al., (2020); |

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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | Ruohomaa et al., (2020); Maurer, (2021) |
| **Meso level** | Local ecosystems, industrial networks | Kolloch and Dellermann (2016); Gorecky et al. (2019); Beltagui et al. (2020) |
| **Micro level** | Companies, consumers | Rao and Jimenez (2011); Suseno et al. (2018); Rocha et al. (2018); Rocha et al. (2019); Yin et al. (2020); Raabe et al.  (2021); Rocha et al. (2021) |

Table 5. Distribution of the literature by system levels

Figure 4 illustrates the distribution of the articles by system levels in %. As one may see the most attention on the scientific literature was paid to macro level (32%) – these studies explored the role of DIE in regional and national development. The studies of the DIE in the internal context of the companies take the second place together with the universal meta level studies, both 28%. The studies on local ecosystems and industrial networks take third place (12%).

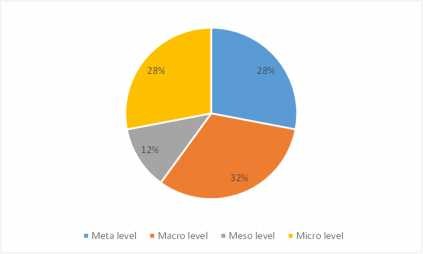


Figure 4. Distribution of the literature by system levels in %

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*Macro level DIEs*

Misseri (2013) in her qualitative analysis for the emergence of DIEs on the example of Picardy region in France claims that the DIE is a pathway for local innovation regardless the characteristics of the territory; the main DIEs’ goal is to support the coevolution of stakeholders involved in the growth, competitiveness and attractiveness of the territories. DIEs will also help to promote weak and strong ties in the territory, produce knowledge and value, and provide access to knowledge and services although the role of “personalities” and think tanks that disseminate their ideas and vision has to be defined in the future. Misseri (2013) also highlights five major components of DIEs - innovation platforms or specific communities (API); web 3.0 principles and technologies; services related to innovation and potential customers; the business model of the platform and the production of knowledge and strategic analysis; a user-centered and personalized environment. Pistorio et al. (2018) stress the key role of policymakers in the development of DIEs; the authors state that governmental organizations can support the growth of an innovation ecosystem through a policy strategy based on a multi-sided platform and through the selection of the required standards to support the integration of the future complementary applications. Whyte (2019) analyses developing DIE of industry/government initiatives and infrastructure megaprojects in the city of London; the research reveals that the changes distributed through government/industry initiatives and megaprojects in the DIE have implications for the strategies of associated firms. Baumane-Vītoliņa and Dudek (2020) conducted a case study of the innovation landscape of the city of Krakow in Poland and claim that the functioning of DIEs is possible thanks to digital platforms, which enable customers to connect with each other and exchange value by making transactions. These platforms facilitate the interaction between producers, suppliers and customers within the network, and those interactions lead to the value co-creation. Thus, DIEs can be put into a broader category of platform-based ecosystems. The research of Cvar et al. (2020) discusses differences and similarities of the internet of Things (IoT) application in the DIEs of smart cities and smart villages. The DIE in this research is identified as a multilevel framework of structures, strategies, tools and people; the authors argue that combination of different stakeholders and facilitation of participatory practice contributes to technological development and results in building DIEs, based on public value. The study of Filatova et al., (2020) provides

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theoretical provisions, as well as methodological tools and an appropriate model for managing the innovation ecosystem in order to implement effective innovations in the digital era; based on the current trends in the digitalization development the research identifies three elements of the DIE, which are digital infrastructure, digital tools and digital competences. Ruohomaa et al., (2020) in their case study of the Hämeenlinna city in Finland argue that DIEs are the conductors of the transdisciplinary innovation in order to create profitable new business models. Maurer (2021) studied the Digital Innovation Hub (DIH) on Business Intelligence & Innovation and its possible network of collaborators and co-creators in the region of the Federal State of Vorarlberg in Austria and claims a DIH should act as service center of a DIE providing the access to services, facilities and expertise to a wide range of stakeholders.

*Meso level DIEs*

Kolloch and Dellermann (2016) provide a comprehensive analysis of the interaction between technological and social entities in the energy industry and its impact on the dynamics of an innovation ecosystem; the authors examined that the coevolution of human and non-human actor networks, which is caused by controversies within the DIE. The authors identify DIE as an actor network with human (i.e. organizational) and non-human (i.e. technological) actors. Gorecky et al. (2019) focused their research on the acceleration of technological advancement and adoption of Industry 4.0 technologies in order to support the digital transformation of the modern factories. The authors propose a Global DIE for the Future of Production that unites three types of stakeholders together with tangible and intangible assets: smart-factory labs and technology testbeds, digital capability centers, and industrial showcase-sites and (digital) lighthouses; the stakeholders, and their assets, which are part of the ecosystem, could be connected horizontally. In their research the authors outline the main objectives of the Global DIE, such as: acceleration the development of new industrial applications of Industry 4.0 technologies; facilitation the testing of the interoperability of Industry 4.0 technologies; allowance of the “bench-marking” and “show-casing” of the Industry 4.0 technologies adoption; facilitation of best practices by opening selected factories as showcase-sites and promoting them as (digital) lighthouses; promotion of education and training programs to help companies adopt to Industry 4.0 technologies. Beltagui et al. (2020) investigate disruptive innovation in the

3D printing industry through the exaptation and ecosystems; the main

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purpose of this research was to understand the mechanisms by which disruption takes place in DIEs. The researchers propose that the number and attractiveness of ecosystem niches grow together with an innovation ecosystem. The combination of openness to new entrants and the possibility of these entrants to exapt can increase the potential for internal disruption. The authors claim that that the ecosystem must evolve sufficiently to allow an exaptation-driven innovation to achieve external disruption of incumbents in other ecosystems.

*Micro level DIEs*

Rao and Jimenez (2011) examined how Apple and Google have used third- party led innovation and their corporate strategy to create viable DIEs, through the App Store and the Android platform respectively. Innovation from an ecosystem based approach could be explained by the network externalities, and by understanding the mechanism that were used for relating the different actors; the role of social network was included in the model; the components of the model are - customers, developers, suppliers, hub or disperse "app store", firms - operating system. Suseno et al. (2018) explored the creation of value through the interactions of consumer and professional stakeholders in DIEs and examined the resulting merging of value categories within DIEs and thus exploring the value’ hybridization. In the case of digital innovation, value is created by organisations from their activities and interactions with stakeholders in the consumer and the professional domains that occur within the DIEs of specific market, regulatory and environmental contexts. The research of Rocha et al. (2018) explore how Research and Development (R&D) collaborations in startups can influence digital innovation in Brazilian manufactures; the DIE in this research is considered a strategic asset, since the various collaborations of the start-ups assist them in the development, dissemination and commercialization of digital solutions. In the following study, Rocha et al. (2019) expand their research to open innovation and Industry 4.0 and confirm the central role of DIEs in the development and promotion of digital solutions by the start-ups. Yin et al. (2020) in their research on Sustainable and smart product innovation ecosystem (SSPIE) name DIE as one of the three typical innovation ecosystems together with open innovation ecosystem and platform-based ecosystem; the authors define cyber space, social space, and physical as the components of DIE. The research of Raabe et al. (2021) explored the role of digital innovation units (DIUs) in incumbent firms and claim that DIEs perspective emphasizes a stronger

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focus on an incumbent firm’s partners and its network and DIEs are searched for solutions to business problems through the digital technologies used. Rocha et al. (2021) investigate how R&D collaborations with scientific and business partners contribute to digital transformation of manufacturers in Brazil; the authors state that such incentives as the promotion of technological innovation in the private sector, has the potential to establish a DIE to foster the country’s industrial competitiveness.

*Meta level DIEs*

Vasin et al. (2018) explored the institutional support to innovations at all levels of the system, including the microlevel in order to explain the low efficiency of adapting the innovation system concept in the Russian economy. The authors name the characteristics of the DIEs: the possibility of unhindered interaction of participants in innovation implementation, including cooperation between scientific bodies and government; promotion of cooperation in the R&D domain; creation of an experimental platform with the who are involved in the joint inventive process. Wang (2018), being inspired by the versatility of ecosystem analysis, offers a multilevel, ecological model of a DIE. The author claims that digital technology is present in almost every ecosystem, so many innovation ecosystems are indeed DIEs; the business process ecosystems and industry platform ecosystems are both examples of DIEs at the organizational level, centered on the focal organization. The main nutrients of the DIEs are knowledge and value of innovation; the boundaries of the DIEs are fluid. The study of Chae (2019) presents a general framework for studying the DIE and support the idea of the DIEs boundaries’ fluidity. The author claims that DIE emerges from the interaction diverse elements, both social and technical and evolves over time. Nepelski, (2019) states the DIE consists of various layers. The physical layer relies on large capital and R&D expenditures whereas upper layers include software producers and platforms. Policies should address the characteristics and needs of the actors in each layer. Collaboration between various actors of the DIE – universities, large companies, SMEs, start-ups is a defining characteristic of digital innovation. Large companies create ecosystems that leverage their size to attract smaller companies; the resulting open innovation models dominate the DIE. Wang, (2020) mapped the different forms of digital innovations and their ecosystems on the layers of a multilevel model of DIEs; these layers together with interdependent and co-evolving

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components correspond to the similar processes of natural ecosystems; DIE ha dynamic and open nature, its structure is complex, with actors playing different roles and interacting in different ways. Key attributes of a natural ecosystem can be applied to describe a DIE: number of actors in an ecosystem, rates at with actors join or exit an ecosystem, differences within and between groups of actors, ways actors and their relationships and actions are arranged, and the capacity to endure disturbances. Xu, (2020) claim that DIE has become a new organizational form of enterprise innovation and inter-enterprise competition in the digital era; according to the author the characteristics of DIE are different from traditional collaborative innovation, which requires scholars to expand research ideas and explore new research issues on the topic. Wang, (2021) synthesizes ecological and information perspectives resulting in the information ecology theory and states the DIEs provide an opportunity to explore how IT and digital technologies, can match an ecosystem’s information capacity with the information needs in integrating the parts into the whole ecosystem. The information ecology theory contributes to digital innovation research new insights on the role of digital technologies in innovation, and multilevel interactions in and across DIEs.

***1.3.5 DIEs integrative conceptualization***

In consequence of the in-depth study of the literature corpus, we revealed a number of patterns, as well as some contradictions of the DIE model vision. Regardless of the system level at which the DIE has been considered, there is a clear tendency to mention technology as a meta-factor for the existence of the DIE. In addition, the general trend is the interconnection between the physical and social levels of the ecosystem; institutional context has also an important role in the functioning of the DIE. Figure 5 represents DIE conceptual framework the main four components of the DIEs. These components are: 1) technology – this component comprises digital solutions such as technologies, platforms, services, resources that enable actors to connect with each other and exchange value and knowledge by making transactions; 2) institutional context implies institutional arrangements, public services, policies, local administrations and management that are in operation in the geography of the DIE allocation that create an environment that shapes the activity of DIEs; 3) physical environment in terms of infrastructure, firms tangible assets, capital goods used by the actors and stakeholders (regardless the system level of DIE) to develop and implement

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innovations; 4) social space that includes actors and stakeholders of the

DIEs, organizations, human capital.

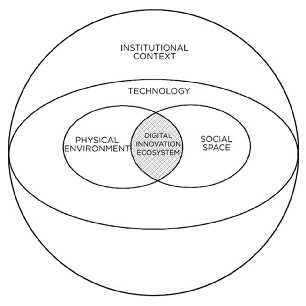


Figure 5. DIE conceptual framework

There are contradictions in the literature on whether to consider the components of the DIE as levels, so that means the hierarchical nature of the DIE or horizontal, when each component is equally important there is also a discrepancy in the literature on the level of independency of the components in the literature. We believe all components of the ecosystem are equally important, exist autonomously, but at the same time are in (close) interaction with each other. At the same time, the technology and institutional context components are meta components, they act as a background in which the other 2 components (Physical environment and Social space) exist. Since the DIE has no clear boundaries, technologies and the institutional context create conditions for the interaction of the physical (Physical environment) and the social component (Social space) and favor the emergence of other DIEs in the field.

**1.4 Conclusion**

Digital transformation occupies an important place in the managerial and scientific discourses. This research discusses the phenomenon of DIEs, its definitions and components. The systematic literature review on the topic shed light on the state-

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of-art in the scientific discussion on the topic and gave insights to the nature of the DIE that contributed to the formulation of the shared definition of the DIE and its components. Four system levels of the DIEs operation were also distinguished and discussed. The main limitation of the study is a limited literature sample; however the literature studied represents a significant contribution to the rising scientific discourse on the topic. The authors deliberately narrowed the range of literature, concentrating only on the literature that discussed DIEs and not other ecosystems that have the similar nature and connotation in order reveal the characteristics of the DIEs as they understand the scholars that use this definition. Thus, the study of the DIE phenomenon at an early stage of its development the findings of our research represent some interesting theoretical, empirical, and policy implications. So, the theoretical contribution of the present study consists of the conceptualization of the discussion on the common elements of DIE in the scientific discourse, which was previously neglected in the literature. DIEs shared definition and conceptual framework could raise the discussion in future scientific studies. The managerial implication of this paper resides in the evidence of the role and place of the organizations in the DIE environment, which has a significant potential to leverage their activity. From an institutional and political viewpoint, the present results can support governments and local administration in improving their role in the DIE context, through research and innovation projects and programs, with the goal of increasing the effectiveness and efficiency of stakeholders’ engagement. These outcomes also have a strong social and economic impact on economic development; hence, the development of DIEs prompts advancements in other spheres of life.

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