

UNDERSTANDING THE KNOWLEDGE ECOSYSTEM: CORE AND FORMS

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Abstract. The *subject* of the article is the theoretical aspects of defining the concept of "knowledge ecosystem". The **purpose** of this article is to elucidate the fundamental characteristics, constituents, and manifestations of the knowledge ecosystem. The authors employ a system-structural analysis to examine the evolution of conceptualisations of the terms "ecosystem" and "knowledge ecosystem". The *methodology* of scientific abstraction and generalisation permitted an investigation into the evolution of the knowledge ecosystem, the definition of its essence and the formalisation of various configurations. The study concludes that there is a growing need to substantiate the concept of the "knowledge ecosystem" due to the increasing transformational role of knowledge in ensuring modern social development. Conversely, the advent of the latest digital technologies (which are themselves valuable knowledge and the result of the knowledge creation process) has led to a revolutionary spread, with all processes, the entire chain of knowledge creation, dissemination and use undergoing changes and transformation. It is proposed that an understanding of the knowledge ecosystem be conceptualised as a system of a consistent and dynamic process of creation, dissemination and use of knowledge at different levels, which is carried out on the basis of sustainable development, self-regulation, environmental friendliness, synergy, and so forth. The authors argue that the knowledge ecosystem should be perceived as a complex and multidimensional phenomenon, with meanings that vary depending on the level, nature and type of knowledge, forms of manifestation and goal orientation. The paper presents a comprehensive vision of the knowledge ecosystem in the aggregate of all its manifestations: the knowledge ecosystem can be formed at the micro (e.g., corporate knowledge ecosystem, university knowledge ecosystem, etc.), macro- (national knowledge ecosystem) and global levels (global knowledge ecosystem); depending on different ways of organisation, a hierarchical, chain, network or platform knowledge ecosystem can be formed; different knowledge ecosystems can be formed depending on the actors (subjects) involved; for different purposes (ecosystems can be aimed at creating new knowledge, and the ultimate goal can be the creation of new value), etc. The key issue in the study and functioning of knowledge ecosystems is their efficiency and focus on the final result. The knowledge ecosystem is formed not only by the totality of all the main actors involved in the process of creating, disseminating and using knowledge, but also largely depends on the system of relations and connections, which in modern conditions are reaching a new level – the level of networks and platforms, creating a favourable environment. The main features of a knowledge ecosystem are: systemicity, environmental friendliness, renewability, sustainability, self-regulation, synergy and emergence. Prospects for studying the functioning of effective knowledge ecosystems prove the relevance of further development of this issue and leave considerable room for further analysis.

Keywords: ecosystem, entrepreneurial ecosystem, digital ecosystem, digital entrepreneurial ecosystem, networked knowledge ecosystem.

JEL Classification: I23, I25, M10, O10, O30

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1. Introduction

The modern development of society is characterised by unprecedented transformational processes that are taking place under the influence of the spread of ICT, the growing role of knowledge and the importance of social and environmental aspects of life. The study of the features and factors of successful development of countries in modern conditions, as well as transformation processes in modern society in general, are the most pressing issues of scientific research. In the works of foreign and domestic economists D. Bell (1973), A. Bowen (2011), M. Castells (1996-1998), D. Lukianenko (2008), F. Mahlup (1981-1984), N. Stern (2006), A. Toffler (1980), A. Chuhno (2005) and many others, the formation of a new type of economy in the general context of global social development is studied at the conceptual level. Ideas about the "post-industrial society" and the "information society" are being expressed, the issue of environmental protection is being updated, and the concepts of sustainable development, green economy, smart economy, etc. are emerging. Recent social changes are largely driven by the new role of knowledge, which is becoming a powerful driver of modern technological and social change. The latest knowledge products are not only changing the entire technological basis of the economy, but also creating a more conscious attitude towards the resources and factors of social development. There is a growing understanding of the need to achieve innovative, sustainable, ecosystemic development.

The realisation of social and environmental issues associated with human development has resulted in the emergence of a novel approach to the analysis of economic phenomena and processes. This approach entails the examination of economic phenomena and processes as integral components of a unified ecosystem. This approach is gaining traction at various levels, including in the perception of the economy as a whole and in relation to individual processes. An analysis of the keywords in scientific publications over recent years reveals a notable increase in research on "entrepreneurial ecosystems," "digital ecosystems," "digital entrepreneurial ecosystems," "knowledge ecosystems," "innovation ecosystems," and so forth. It is essential that any category is clearly defined, that its essence is understood, that its main boundaries and characteristics are identified. The increasing number of publications on this topic reflects not only a growing interest in this category but also a lack of consensus within the scientific community regarding the definition of the concept of "ecosystem".

Therefore, an important issue is to establish the essence of this concept, its evolution, factors,

forms and levels of manifestation, and key features. This task can be solved by systematising and studying scientific approaches to ecosystem research. This should be the basis for the concept of "knowledge ecosystem", which is also actively studied in modern scientific publications.

2. Problem Statement

The use of the concept of "ecosystem" together with the concept of "system" implies a certain widening of the boundaries and filling with new content. The need for the emergence and expansion of such a category is caused by the increasing impact of such global transformation processes as intellectualisation, digitalisation, socialisation, ecologisation, etc. The effect of economic laws and regularities cannot be cancelled, but it is complemented and acquires new important aspects of development. For example, the unprecedented spread of ICTs does not change the essential market dependencies, but it does change the factors and forms of relations and their dynamics. In modern production, the importance of intellectually and informationally saturated capital resources, goods, technologies and highly qualified human resources with professional knowledge and skills to work with them and thus produce qualitatively new knowledge is growing. The latest information and communication technologies are becoming an integral part of the management of processes and relationships between different elements and actors, which a priori takes into account the values and principles of sustainable development. The spread of environmental imperatives in the economy is also taking place everywhere, giving a new emphasis and focus to economic processes.

The pivotal role of knowledge in social development has long been acknowledged as a fundamental tenet in the scientific community. A considerable body of research has been dedicated to elucidating the influence of knowledge on socio-economic advancement. Concurrently, the conventional approach to conceptualising the system of knowledge production and dissemination is undergoing a period of expansion, which can be exemplified by the introduction of the term "knowledge ecosystem" into the lexicon. It is therefore imperative to delineate the distinctive characteristics of the concepts of "ecosystem" and "knowledge ecosystem".

The purpose of the article is to clarify the essence, features and forms of manifestation of the knowledge ecosystem. To achieve this goal, the article analyses the evolution of views on understanding the concept of "ecosystem", its spread and definition using the method of system-structural analysis of the phenomenon of "knowledge ecosystem".

3. Results

In general, the term "system" is understood as a set of mutually coordinated elements that have a common goal, form a single whole, and interact with the environment and with each other. There are many definitions of a system, as well as studies of its properties within the framework of systems theory, contributed by such scientists as R. Ackoff, Béla H. Bánáthy, L. von Bertalanffy (Ackoff et al., 1968) and many others. In the modern dictionary of the Ukrainian language a system is defined as "a set of arbitrary elements, units, parts united by a common feature, purpose" (Slovnyk), "a set of relations forming an identifiable unit, real or conceptual" (Laszlo, Margenau, 1972).

The advent of the term "ecosystem" and its proliferation across diverse disciplines can be attributed to the necessity to accentuate novel facets of systems. The aforementioned new aspects (relating to the consideration of the ecological context and the coordination of interests of all parts, among others) will become apparent if one traces the evolution of the concept of an ecosystem. The evolution of the concept of "ecosystem" has been studied by a number of researchers, including M. Krivý (Krivý, 2003), F. B. Golley (Golley, 1993), M. Koch (Koch, 2022), W. Li (Li, 2012), and others.

The term "ecosystem" first appeared in ecological research. It was first used by the English ecologist Arthur Tansley in 1935 and further developed by Raymond Lindeman in 1942 (Lindeman, 1942). Eugene Odum's *Basic Ecology* (1953) (Golley 1993: 188) gave the concept of ecosystems a firm foundation. In his view, human society and the abiotic environment function together to form an ecological system or ecosystem. The ecosystem is the basic functional unit in ecology because it includes both organisms and the inanimate environment – components that mutually influence each other's properties and are necessary to sustain life as it exists on Earth (Odum, 1986). Ecosystems are thus viewed in ecology as the unity of living and non-living nature.

It is important to acknowledge that the question of the unity of living and non-living nature has been a topic of interest for scientists for some time. In the early twentieth century, Vernadsky articulated the concept of the biosphere as a unified sphere encompassing both living and non-living entities. Vernadsky proposed that the substance of the biosphere is composed of the following elements: living matter (the biomass of modern living organisms); biogenic matter (all forms of detritus, as well as peat, coal, oil and gas of biogenic origin); and the biocosm (mixtures of biogenic substances with minerals of non-biogenic origin). The term "biogenic substances" encompasses a range of materials that have been

altered by living organisms, including soil, silt, natural waters, gas and oil shale, bituminous sands, and part of the sedimentary carbonates. The term "space substance," on the other hand, refers to rocks, minerals, and precipitation that have not been directly affected by the biochemical processes of organisms.

Vernadsky's legacy also encompasses the doctrine of the noosphere, which posits that the biosphere will enter a new state in which the mind and human labour, directed by the former, will manifest as a geological force unlike any previously observed on Earth. Vernadsky identified several general conditions that must be met for the creation of the noosphere. Firstly, humanity must unite economically and informatively. Secondly, the noosphere is a universal phenomenon, therefore humanity must achieve complete equality between races and peoples, regardless of skin colour and other differences. Thirdly, the noosphere cannot be created until wars between peoples cease (Vernadsky, 1944).

As Sabine Hohler has observed, the ecosystem can be conceptualised as an analytical and mathematical structure, the boundaries, scale and standards of which are contingent upon the scientist's perspective (cited by Krivý, 2003). While L. von Bertalanffy did not refer to an ecosystem, he did develop a paradigmatic concept of general systems theory. The scientist examined biological entities as organised, dynamic systems, which are conceived as a mathematical abstraction designed to describe and study systems that evolve over time. In accordance with Odum's theory, ecosystems are open systems. Consequently, an essential element of his concept is the distinction between the output environment and the input environment (Odum, 1986).

This sense remains in the modern understanding of the concept of ecosystem. It is assumed that such a system takes into account the needs of wildlife and the environment, whatever the system and whatever the area. Subsequent and current research has significantly broadened the definition of the concept and added new dimensions. At the same time, the environmental context is almost always present. This can be explained by the fact that nature itself is the most perfect system. As J.F. Moore noted, biological examples can explain the most complex systems: "Every time you master a biological example, you learn a systems concept that will be valuable in understanding the dynamics of business in the new economy." (Moore, 1996)

It can be argued that the defining characteristic of an ecosystem is its intrinsic interconnectivity between living and non-living entities. This perspective is supported by the work of F. Sussan and Z. Acs, who posit that the interaction between these two domains is inherently dynamic and ever-changing, influencing the collective behaviour of the ecosystem (Sussan, 2017).

An important issue in understanding ecosystems is their properties. The main theoretical approaches to understanding ecosystems were set out by Ron Adner. He emphasised that all parts of an ecosystem should not only be consistent with each other. In a rigid hierarchical system, there is also coordination between the parts, but it can be carried out with strong coercion, disregard for the interests of its subjects, and subordination of all their actions to a common goal. The ecosystem approach means balancing the interests and positions of its actors. Indeed, Adner defines an ecosystem in this context: "the alignment structure of the multilateral set of partners that must interact to realise a focal value proposition" (Adner, 2017). In addition, as mentioned above, Odum emphasised one property of an ecosystem as stable equilibrium – the ability to return to its original state after a deviation. This means that every ecosystem is a self-regulating system. Like systems, ecosystems have properties such as emergence and synergy.

In his conceptualisation of the knowledge ecosystem, Ron Adner also proposed a structuralist approach to defining the design of the ecosystem, characterising its structure and various aspects of ecosystem strategy. In his understanding, an ecosystem can be defined as a membership and as a structure. Adner distinguishes between these two general views: (a) ecosystem as affiliation – considers ecosystems as communities of associated actors defined by their networks and platform membership; and (b) ecosystem as structure – considers ecosystems as configurations of activities defined by a value proposition.

The meaningful capacity of the concept of ecosystem has become the basis for the widespread use of this term in various fields of human activity, and not only in ecology. This has been happening gradually since the end of the last century. There are attempts to consider economic phenomena as an ecosystem. Such attempts are made in a broad research context, when economic phenomena and processes are part of the interaction of biological, physical, ecological and other processes. In business research, the term "ecosystem" was first used in 1996 by J. F. Moore, who formulated the idea of a business ecosystem, which he defined as an economic community in a state of intense co-evolution, coalescing around innovative ideas (Moore, 1997). Biological ecosystems have become the prototype for business ecosystems, but there are differences. Whereas biological ecosystems evolve very slowly, business ecosystems can co-evolve very quickly, based on the decisions of their participants. Innovation has become the starting point for ecosystem research, and not just at Moore. The problems of innovation ecosystems are studied by the Ukrainian scientist L. Fedulova (2015).

Subsequently, the methodology of examining the economy as an ecosystem has gained considerable

traction in the scientific community, with applications extending to a diverse array of economic phenomena and processes. Z. Acs delineates an ecosystem as a biotic community that encompasses its physical environment and all the interactions that are possible in a complex of living and non-living components (Acs, 2017). Whitmore defines the global ecosystem as a combination of the following 11 components: Slowly renewable basic resources (clean air and ocean water); naturally renewable resources, consisting of various combinations of fresh water, soils, plants and animals; processed/transformed for sale renewable resources (harvested, frozen, preserved, smoked, refined, pasteurised, transported and various other forms of naturally renewable resources); human populations; non-renewable non-extractable resources (fossil fuels and minerals); extracted/transported commodity resources; capital goods; consumer goods; public infrastructure (roads, bridges, airports, seaports, power plants); treated and stored waste; untreated waste (pollution) (Whitmore, 2007).

Moreover, the most common perception of this category is that of an entrepreneurial ecosystem. Z. Acs et al. define entrepreneurial ecosystems as "the dynamic, institutionalised interplay between the entrepreneurial attitudes, capabilities and aspirations of individuals that guide the allocation of resources through the creation and operation of new ventures" (Acs, 2014). F. Sussan and Z. Acs define entrepreneurial ecosystems as dynamic, institutionalised interactions between individuals' entrepreneurial attitudes, capabilities and aspirations that guide the allocation of resources through the creation and operation of new ventures. At the socio-economic level, they have the characteristics of self-organisation, scalability and sustainability and consist of subsystems and systems (Sussan, 2017).

A well-known researcher of the entrepreneurial ecosystem phenomenon, Ben Spigel, sees them as "a type of cultural, social, economic and political environment in a region that supports highly developed entrepreneurship" (Spigel & Harrison, 2017), "a set of interdependent actors and factors that are coordinated in such a way that they promote productive entrepreneurship in a given area" (Spigel, 2020). Spigel (2017) posits that an entrepreneurial ecosystem comprises three principal resources: a shared cultural understanding and institutional environment, social networks facilitating knowledge transfer between firms and universities, and a material component.

In this approach, it is important to emphasise efficient entrepreneurship, which includes the synergistic effect of their interaction and creates value not only for the entrepreneur but also for society as a whole. The introduction of new technological innovations increases efficiency or reduces barriers in markets.

Entrepreneurial ecosystems are driven by individual-level actions, but they are embedded in multipolar interactions between individual and institutional actors. Much of the knowledge required for entrepreneurial activity is embedded in ecosystem structures and requires individual-level action to extract it. What Spigel sees as an important feature of entrepreneurial ecosystems is that they belong to a particular territory. In other words, entrepreneurial ecosystems are a geographical phenomenon, not a sectoral or industry-specific phenomenon.

As Wenjie Li and others have observed, a key distinction between ecosystems and traditional systems is the absence of formal authoritarianism to coordinate actions (Li, 2017). Bart Clarysse offers a definition of an ecosystem through the lens of a value network, defining these as "business ecosystems where the value proposition is offered by a group of companies that are mutually complementary" (Clarysse, 2014). It is through such value networks that companies can realise their competitive advantages. Brice Dattée, Oliver Alexy, and Erkkö Autio examine the process of creating ecosystems and emphasise the necessity for organisations to exert control over this process. They posit that "firms ... need to learn to keep up with ecosystem dynamics by roadmapping and preempting, while simultaneously enacting resonance" (Dattée, 2018).

As posited by D. Audretsch, M. Belitsky, and N. Cherkas, entrepreneurial activity in disparate geographical contexts and ecosystems is predicated on three institutional pillars: regulatory, cognitive, and normative institutions that provide incentives for entrepreneurial behaviour (Audretsch, 2021). The term "ecosystem" has become a commonplace in the field of management, where it is used to describe a network of organisations that are connected to or operate around a lead firm or platform. These ecosystems are characterised by a focus on the development of new value through innovation (Autio, 2014).

Ron Adner underscores the significance of the ecosystems concept in discerning and bolstering interconnections that have the potential to yield remarkable benefits, irrespective of the scale of the systems in question. In the contemporary business environment, organisations are engaged in a competitive pursuit to integrate disparate actors in order to develop robust end-to-end solutions or experiences. Subsequently, they endeavour to establish thriving business ecosystems, dedicated to the delivery of these solutions to customers (Adner, 2017).

The evolution of the term "ecosystem" continued and saw the emergence of new content as a result of the digitalisation process, which led to the advent of the term "digital ecosystem". The concept was

initially articulated in the report "Digital Ecosystem" by HP CEO Carla Fiorina in 2000 at a meeting of the influential non-profit organisation World Resources Institute. Fiorina (2000) observed the advent of "a unified global ecosystem, interconnected, overlapping, and mutually influencing, benefiting from each other's successes and bearing the brunt of each other's failures" (Fiorina, 2000). It was crucial not only to introduce a new term but also to substantiate the global nature of all processes and the interconnectivity of the virtual and physical realms.

There are various methodologies for defining this category, but in general, it emphasises the opportunities that digital technologies bring. Digital technologies and digital products are an indispensable component of any digital ecosystem. In their definition of a digital ecosystem, Wenbin Li, Youkim Badr, and Frederique Biennier describe it as a self-organising, scalable and resilient system composed of heterogeneous digital objects and their interconnections. The focus is on the interaction between objects to enhance the system's utility, generate benefits and facilitate information exchange, internal and mutual cooperation and system innovation (Li, 2012).

According to R. Purbasari, Z. Muttaqin, S. Sari, a digital ecosystem is a "digital environment" in which "digital species" or "digital components" live (Purbasari, 2021). Matthias Koch et al. define a digital ecosystem primarily in terms of digital platforms: "A digital ecosystem is based on the provision of digital ecosystem services via digital platforms that enable scaling and the exploitation of positive network effects." (Koch, 2022) Dini and Nachira define a digital ecosystem as a digital software environment that supports the development of distributed and adaptive technologies and evolutionary business models for organisations (Digital business, 2007). D. Tilson provides a clear definition of digitalisation as both a technical process and a socio-technological process. The latter refers to the broader social and institutional context in which digital technologies are applied, thereby making them infrastructural (Tilson, 2010). C. Smith defines an ecosystem as an interaction that provides entrepreneurs with access to resources that can be used to achieve desired results (Smith, 2017). S. Kraus elucidates the concept of digital ecosystems through the notion of bridges and connections. Bridges facilitate connections between actors in the network, aiming to establish as many connections as possible to gain access to novel knowledge (Kraus, 2018).

The development of digital technologies is embodied in the emergence of a wide range of tools and mechanisms that radically change the human environment, transforming all forms of communication and interaction. The development of digital technologies is embodied in the emergence of a wide

range of tools and mechanisms that fundamentally change the human environment, transforming all forms of communication and interaction. The interaction of animate and inanimate (digital) nature results in the formation of a digital ecosystem.

As a result of the development of ecosystem and digital ecosystem research, a new concept has emerged – digital entrepreneurial ecosystems. For entrepreneurs, a digital ecosystem is not only a business model, but primarily a digital innovation platform that provides innovators with an environment to test ideas and implement digital solutions based on cooperation agreements (Song, 2019). In his research, A. Song identified three components of digital entrepreneurial ecosystems: digital user citizenship (DUC), digital technology entrepreneurship (DTE), and digital multiparty platforms (DMP) (Song, 2019). According to A. Cavallo, digital entrepreneurial ecosystems can be local, global or even larger. Their size depends on the adaptation, absorption, and diffusion of digital technologies (Cavallo, 2018).

In most definitions of digital entrepreneurial ecosystems, an important component is not just entrepreneurship, but digital entrepreneurship. For example, Davidson et al. (2010) argue that digital entrepreneurship consists of three interrelated types of entrepreneurship: entrepreneurship per se, knowledge entrepreneurship and institutional entrepreneurship. Digital entrepreneurship is a multifaceted phenomenon that encompasses all three types. According to F. Sussan and Z. Acs, digital entrepreneurial ecosystems consist of entrepreneurs who create digital businesses and innovative products and services for a wide range of users and agents in the global economy. The outcome of a digital entrepreneurial ecosystem is a sustainable ecosystem (Sussan, 2017). However, as W. Li et al. (2017) observe, "digital entrepreneurship is just one stream of entrepreneurship".

The concept of ecosystems is closely related to the emergence of networks and platforms, so in addition to the above concepts of ecosystems, the scientific literature studies innovation ecosystems (Fedulova, 2015; Wessner, 2004; ITU), digital innovation ecosystems (ITU-D), platform ecosystems (Kretschmer, 2022), digital platform-based ecosystems, digital platform-based business ecosystems (Cozzolino, 2021; Szerb, 2022), digital platform ecosystems (Hein, 2020). An innovation ecosystem is understood as a set of complex relationships between different actors in the innovation economy (individual entrepreneurs, corporate actors such as large companies and universities) and emphasises the importance of incentives for different actors to create an innovation-friendly environment (Fedulova, 2015). The proliferation of platforms makes it important

to study their characteristics and correlation with ecosystems (Gawer, 2021; Platform ecosystems).

In general, two approaches can be distinguished in the study of ecosystems. In a general theoretical sense, the phenomenon of the ecosystem itself, its nature, evolution and characteristics are studied. At the same time, the ecosystem often becomes an object of study in management. In this case, an ecosystem is most often considered as a local system of a particular business (for example, an automotive service ecosystem). Alternatively, an ecosystem is a system of business relationships aimed at achieving value creation goals (Platform ecosystems). In the general theoretical context, the concept of an ecosystem is much broader than just a targeted focus on value creation. For example, I. Kalenyuk and I. Uninets argue that it is necessary to understand the smart economy as an ecosystem, since the smart economy is basically a system of mutual coordination of interests and actions of various actors based on sound management, taking into account important values of sustainable development and the use of the latest ICT (Kalenyuk, 2021).

Such an expansion of the categorical apparatus demonstrates the complexity and evolutionary nature of modern transformational processes taking place in the economy under the influence of digital technologies. Moreover, the speed of change and the breadth of its penetration are transforming the entire economy, the system of interconnections and the main actors in relations. The ecosystem as a phenomenon and as a theoretical construct is evolutionarily growing and developing in line with changes, new needs and circumstances.

Thus, the following important features can be identified in the definition of ecosystems: Firstly, it is systemic (i.e., a holistic form of association of various objects); secondly, the existence of close interconnections between the subjects and the formation of a new type of interaction in general – network; thirdly, the formation of an environment favourable both for the subjects themselves and for the global space of human activity; in an ecosystem, there is a systemic interaction between living and non-living nature; fourthly, self-organisation and renewability.

The analysis of the evolution of the concept of "ecosystem" logically leads to the emergence of the concept of "knowledge ecosystem". The growing importance of knowledge in social development is also reflected in the penetration of this concept into economic and management research. In his seminal work, "The Fifth Discipline: The art and practice of the learning organization" in 1990, Peter Senge conceptualised the notion of a "learning organisation" in which "people continually expand their capacity to create the results they truly desire". In a learning

organisation, new creative thinking models, collective aspirations and "people constantly learning to see the whole together" are supported (Senge, 1990).

In his study of knowledge ecology, George Pór posits that the development of an organisation's knowledge ecosystem facilitates the unlocking of the potential of its members' creativity and collaboration, thereby enabling the acquisition of the collective knowledge or collective wisdom of the organisation (Pór, *The Knowledge Ecology*, 2001). Further, in defining the knowledge ecosystem of a business organization, he notes that it is a more reliable indicator of its future performance than its financial strength. Financial results indicate the past performance of an organization, while the strength of its knowledge ecosystem indicates its potential to meet new challenges and requirements. To meet new challenges, organizations must strengthen the shared knowledge and intelligence of their members. "A company can have billions of dollars in the bank, but if that company is not in tune with the requirements of knowledge-based economy, it's very likely that it will not survive" (Pór, *Management Education and Knowledge Ecology Ecosystems of knowledge generate social and economic value for businesses*, 2001).

In her study of the evolution of knowledge, Verna Allee observed that the slogan "knowledge is power – so hoard it" was once a pertinent assertion. In the contemporary information age, the slogan has evolved to "knowledge is power – so share it and it will multiply" (Allee, 1997). In their analysis, Wenbin Li and colleagues highlight the importance of self-organisation in knowledge ecosystems, particularly in response to environmental change. This contrasts with the traditional focus on managing outcomes (Li, 2012). A. I. Vodă, S. Bortos, & D. T. Şoitu define a knowledge ecosystem as a system of interconnected components that work together to create, share, and use knowledge. They consider the main attribute of a knowledge ecosystem to be the generation of new knowledge and valuable open solutions for participants that stimulate innovation, improve decision making, and support learning and growth (Vodă, 2023).

Additionally, Giedrius Jucevičius associates the knowledge ecosystem with the advancement of novel knowledge. Furthermore, he postulates that the knowledge ecosystem can be expanded to address "wicked problems" in intricate social contexts. The efficacious resolution of wicked problems is contingent upon the establishment of effective ecosystems that serve as platforms for accessing and managing diverse social knowledge (Jucevičius, 2022).

The approach of Kati Järvi, who identified two principal methods of organising a knowledge ecosystem – namely, prefigurative and partial – has become a significant topic of interest within the field of scientific research. In a knowledge ecosystem

organised in a prefigurative form (for the identification of a knowledge domain), actors whose participation is affiliated, independent, and optional explore this domain with the objective of identifying and establishing common knowledge as a basis for collective action. This is achieved without the necessity for formal rules or coordination mechanisms. In a partially organised knowledge ecosystem, where the knowledge domain is already defined, participants seek and discover knowledge related to problems and solutions by participating through formal membership and access to resources. Their contributions are subject to control (Järvi, 2018).

The knowledge ecosystem is a systemic phenomenon, intrinsic to its very nature. It would be beneficial to attempt to characterise it in different ways. To illustrate, if the life cycle of knowledge is taken as a basis, from its creation to actual use, a knowledge ecosystem can be defined as an interconnected set of successive stages of knowledge creation, transfer, dissemination and use. It is the sequence and constant reproduction of this cycle that constitutes the knowledge ecosystem. The generation of new knowledge is ultimately manifested in its transfer to other entities or institutions. The creation of knowledge is not the end goal; rather, it is created with the intention of being disseminated in society. However, the extent to which this occurs varies depending on the value and scope of the knowledge in question. In essence, all knowledge is created with the intention of contributing to societal development. The utilisation of recently created and disseminated knowledge invariably serves as the foundation for the generation of a demand for novel knowledge. Therefore, this knowledge cycle can be defined as an ecosystem of knowledge creation and utilisation, representing a constant spiral of knowledge accumulation by humanity (Figure 1).

Nevertheless, the specific characteristics of a knowledge ecosystem may vary depending on the intended objective. It is not uncommon for the objective of a knowledge ecosystem to be the generation of novel knowledge. To illustrate, the ecosystem of a university or research institution comprises a multitude of scientific laboratories and research teams, collectively striving to address specific problems. These institutions represent the nucleus, the pivotal nexus within the knowledge ecosystem. All other services revolve around this nucleus, facilitating interaction within a unified university ecosystem. The overarching objective of this ecosystem is to generate new knowledge, disseminate it to students during the learning process, and facilitate its further propagation. This can be knowledge of different levels, including a new curriculum, a new discipline, or a graduate who has acquired new knowledge and skills, as evidenced by a diploma,

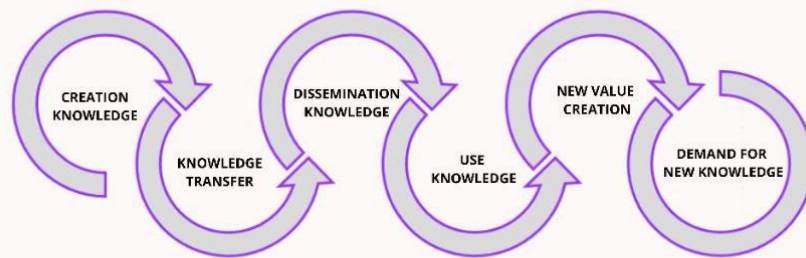


Figure 1. The process of creation, dissemination and utilisation of knowledge

and subsequently enters the labour market with an enhanced human capital. In each of these instances, the ecosystem has successfully attained its intended outcomes. Its subsequent impact on the subsequent ecosystem or chain may serve as a source of new value.

On the other hand, there are ecosystems that are directly aimed at creating new value, and these are business ecosystems. The ultimate goal of the knowledge ecosystem of a particular business is usually to create value. In this case, the knowledge ecosystem is complemented by another link. In the ecosystem of a business organisation, the ultimate goal is not just

new knowledge, but value creation. The core of the business organisation's ecosystem is also the research department. However, the process of creating new knowledge involves the whole organisation and the work of HR and others (Figure 2).

In the general theoretical context, a knowledge ecosystem is a system of certain subjects, actors and the entire set of relations between them regarding the creation, dissemination and use of knowledge. These actors include universities, research institutions, business organisations, government agencies in the field of education and science, NGOs, etc. In general,

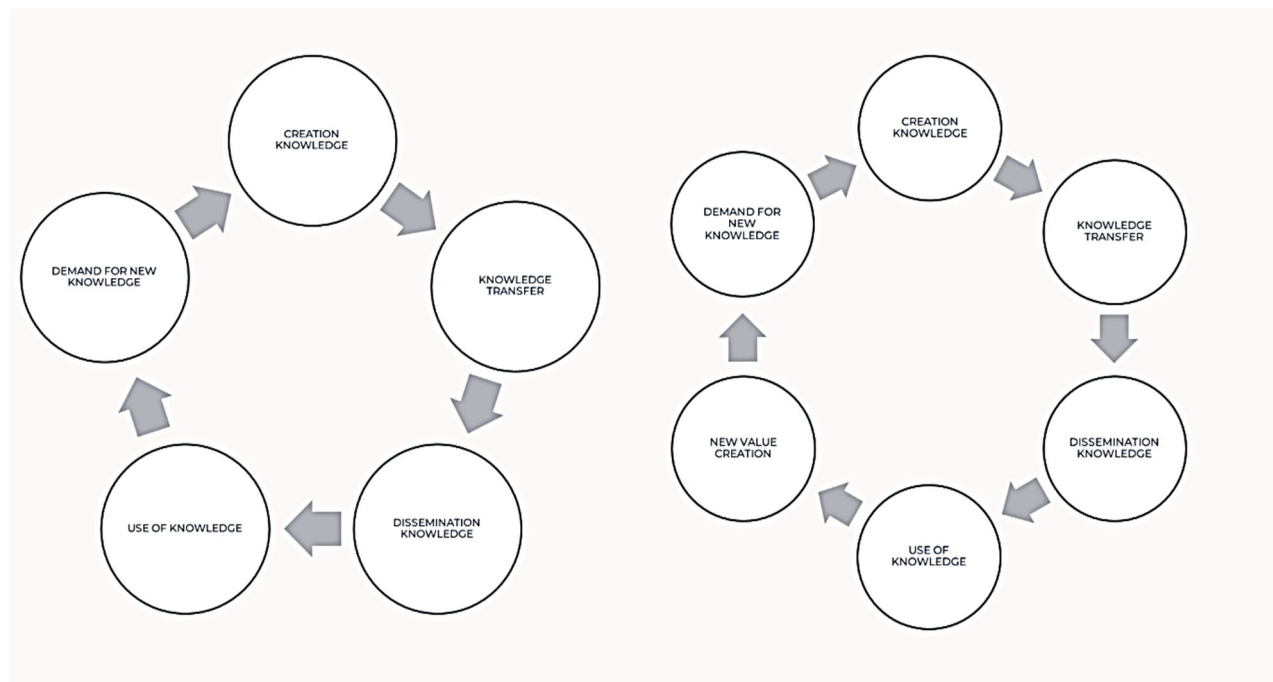


Figure 2. Goals of the knowledge ecosystem

the range of actors can be significantly expanded and diversified. Mixed actors are emerging: public-private, or mechanisms of cooperation between public and private actors in the field of creation, transfer or use of new knowledge (Figure 3).

The knowledge ecosystem can be viewed at different levels: at the micro level (university, company, etc.); at the industry level (the knowledge ecosystem of a particular business – software production, etc.); at the macro-level; and at the global level (Figure 4).

The configuration of a knowledge ecosystem may be classified as either hierarchical, chain-like, or network-based. In the past, the hierarchical ecosystem was the norm, with a system of knowledge creation, dissemination and use that followed a clearly defined order. The accelerated evolution of contemporary digital technologies is profoundly influencing the technological foundation and the comprehensive system of economic interactions within society. All transactions are accelerated, and all interactions,

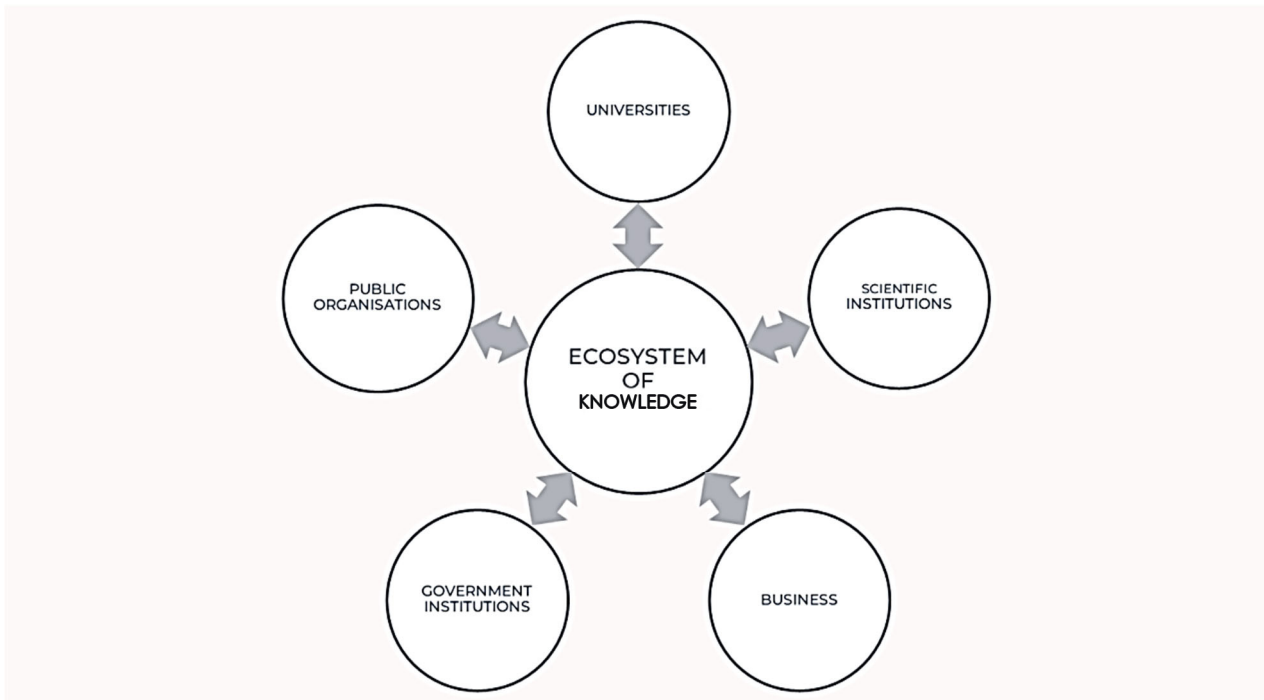


Figure 3. Actors of the knowledge ecosystem

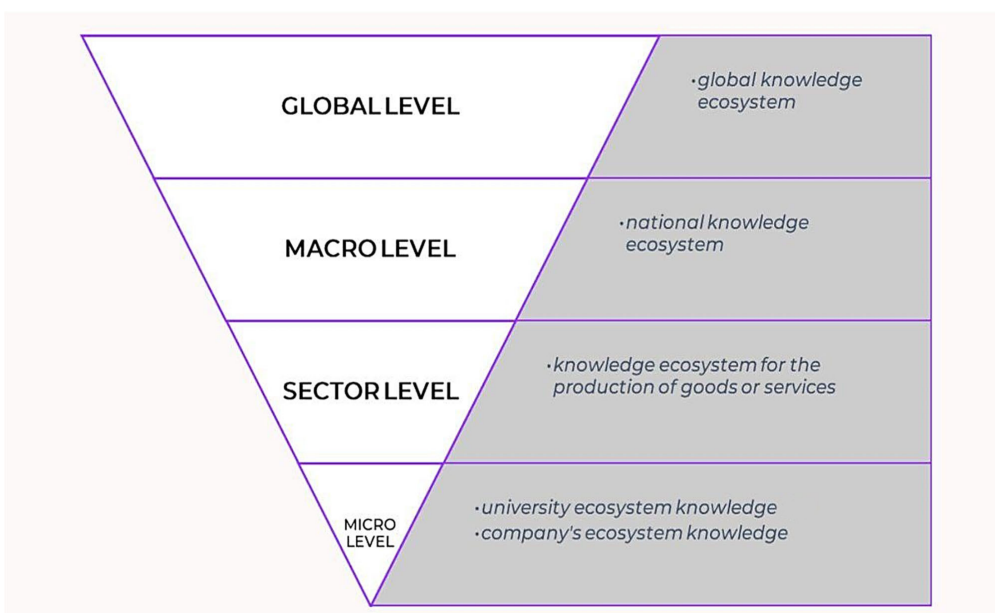


Figure 4. Levels of the knowledge ecosystem

mechanisms and tools for implementing economic activities are transformed as a result. The network nature of economic interactions is evolving, becoming more flexible, adaptive, and interactive. The costs associated with transactions are significantly reduced, while the volume of virtual, intangible forms and products of activity is growing. The proliferation of networks, in turn, contributes to the emergence of new forms of business, including the creation of platforms and online systems that combine two-sided markets – that is to say, those based on the interaction of buyers and sellers – based on the use of standardised integrated solutions (see Figure 5). Examples of such platforms include Amazon and Uber, which facilitate interactions between a vast number of buyers and sellers, thereby streamlining transactions.

The increasing interconnectivity of economic transactions also influences the entirety of the knowledge creation and utilisation process (Figure 6). At each stage of the knowledge chain, a multitude of actors can be involved, thereby forming a complex system of relationships between them. The creation of knowledge is no longer the exclusive domain of research institutions. It is possible that the ecosystem may comprise actors who are directly related to only one of the links in the processes of knowledge creation, dissemination and use. Furthermore, organisations as a whole may also become participants in this process, whereby the interaction and cooperation of all departments result in the creation of new knowledge (i.e., a learning organisation). A salient feature of the knowledge ecosystem is that all its constituent elements are not merely oriented towards the generation of novel knowledge. An environment is established that fosters interaction, collaboration, knowledge sharing, and, in general, the expansion of organisational knowledge. As defined by P. Senge, a "learning organisation" is

characterised by five key attributes: personal mastery, systems thinking, team learning, shared vision and the surfacing of mental models (Senge, 1990). The number of opportunities and tools for the dissemination and utilisation of knowledge is increasing.

In consideration of the external environment, knowledge ecosystems may be characterised as either open or closed. Furthermore, the nature of the knowledge in question can also serve to differentiate between the various types of ecosystems. It can be posited that the function of a knowledge ecosystem is to facilitate the generation of novel knowledge. Concurrently, new knowledge may manifest in diverse forms, including tangible (embodied in products or services) and intangible (virtual knowledge, organisational knowledge, etc.). In his seminal work, Nonaka (1991) posits a model of knowledge creation and transfer, wherein explicit and tacit knowledge are created, transferred and exchanged during the processes of socialisation, externalisation, combination and internalisation. Nonaka's model has gained considerable traction and is regarded as a notable advancement in the field of ecosystem theory (Sabu, 2017).

New knowledge can be represented as theoretical knowledge and applied knowledge. Theoretical knowledge can be knowledge about the nature and characteristics of a phenomenon or process, new research methods, techniques or tools, analytical characteristics, identification of stable patterns, modelling of dependencies, etc. Applied knowledge usually has a specific expression – a technology, a new development, a new product or know-how.

Knowledge can be new absolutely when something qualitatively new is created for the first time. It is also possible that knowledge is new in a certain ecosystem. For example, in the process of educating and training

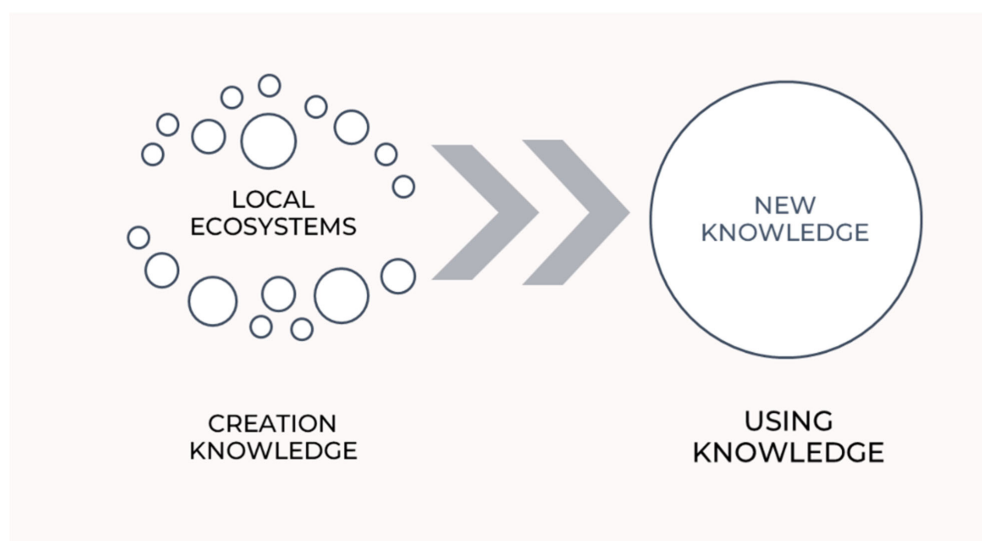


Figure 5. Chain knowledge ecosystem

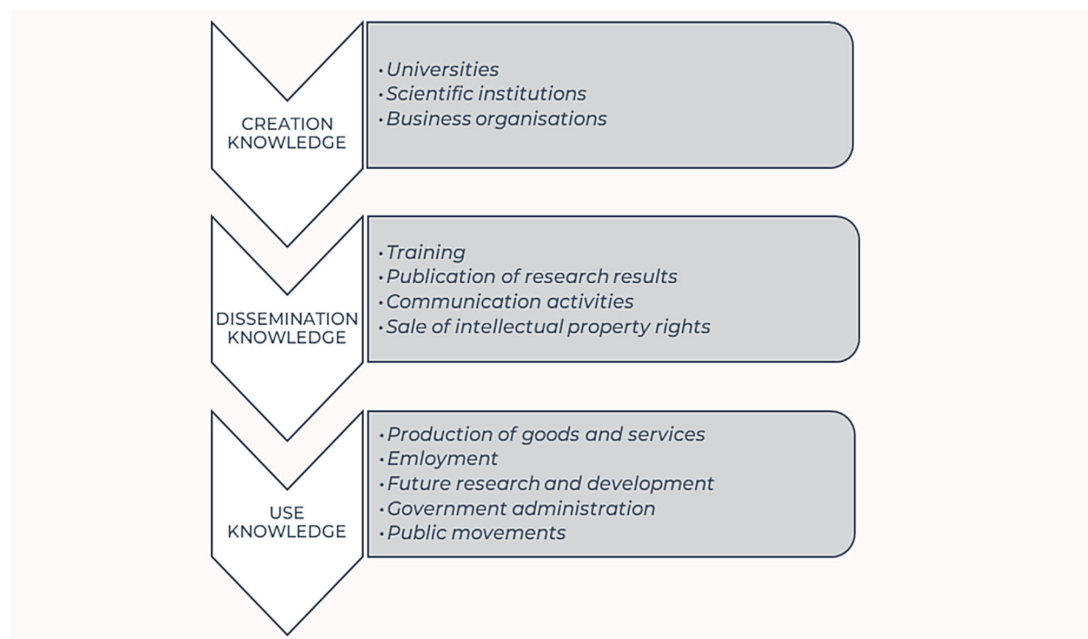


Figure 6. Knowledge lifecycle

specialists, a situation is analysed and various solutions are worked out to come to a certain conclusion. In this situation, knowledge is new to this environment. But it is no less important because it contributes to the growth of human capital. In addition, the collaborative form of acquiring new knowledge can always provoke a synergistic effect that will lead to the emergence of even more new knowledge.

Knowledge creation can take place in a particular field or industry. However, knowledge can also be interdisciplinary in nature, when developers from different fields participate in its creation. In addition, the application of new knowledge can be wide-ranging and generally have a multiplier effect.

Thus, the design of a knowledge ecosystem can take on different configurations and have different complexity, manifesting itself at different levels and scales. In all cases, any system of creating new knowledge can be considered an ecosystem if it is sustainable, self-regulating, ecological and constantly renewing. A knowledge ecosystem is not just a set of all the main actors involved in the process of knowledge creation, dissemination and use. It largely depends on the system of relations and connections, which in modern conditions are reaching a new level – the level of networks and platforms, creating a favourable environment (Figure 7). The main features of the knowledge ecosystem are: systemicity, environmental friendliness, renewability, sustainability, self-regulation, synergy and emergence.

An important issue is to build a system of relationships that best facilitates the realisation of tasks at each stage. The complex process of knowledge creation should end with the emergence of new

knowledge. Its effectiveness depends both on the ingenuity of individual researchers and on teamwork. In both cases, the key factor is the creation of an environment that supports creativity, the exchange of ideas, joint collaboration and initiative. The extent to which the ecosystem is tuned to the end result depends on the whole range of measures taken to organise it. Sufficient incentives for researchers are also important: adequate remuneration and incentives. In general, the issue of building an effective knowledge ecosystem is extremely relevant in the management literature (Almeida et al., 2019; Byukusenge, 2017; Dikert, 2016; Imran, 2017; Ouriques, 2018 et al.). M. Li, H. Liu, & J. Zhou distinguish three main ways of knowledge creation (individual experience, individual communication, and organisational knowledge acquisition), and the main way of knowledge creation is its practical assimilation (Li, 2018). T. Jackson, L. Jackson, & M. Day explore new ways of creating knowledge (Jackson, 2023). The concept of knowledge sharing is explored by P. Massingham, who develops new models for the creation of knowledge and its relationship with research and operational innovations (Massingham, 2015). Similarly, F. Bjørnson and K. Vestues investigate the link between the generation of knowledge and the realisation of flexible development (Bjørnson, 2016).

The efficacy of knowledge dissemination is contingent upon the multiplicity and efficiency of the knowledge transfer channels employed. In general, this process is now referred to less frequently as transfer or dissemination and is more commonly described as "sharing," which is a broader term. The advent of

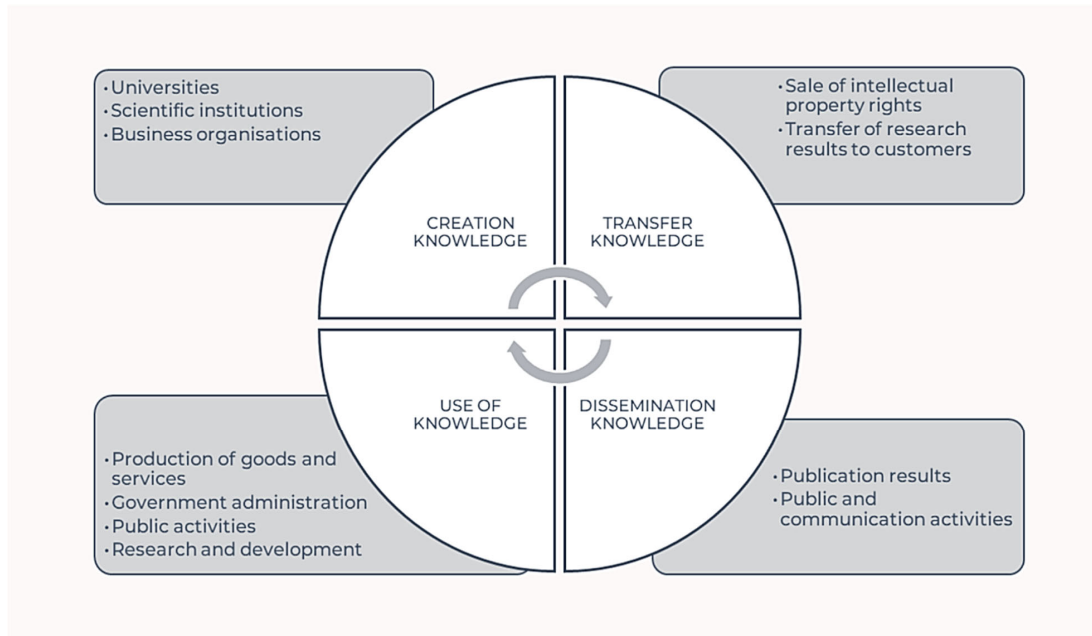


Figure 7. Knowledge ecosystem

modern technologies has created unprecedented opportunities for the acceleration and implementation of transactions pertaining to the dissemination of knowledge. The sharing of knowledge can be conducted on a commercial, non-commercial, or mixed basis. In a recent study, Asiamah Yeboah analysed 110 scientific articles on knowledge sharing and identified three key research areas: knowledge sharing tools, knowledge sharing processes, and knowledge sharing outcomes (Yeboah, 2023).

Knowledge is used in all sectors of the economy and society as a whole. However, the readiness and willingness to accept new knowledge can vary. Businesses are the most motivated, as new knowledge is the basis of their profits and competitive advantages. At the same time, it is also important for all other sectors of the economy to be ready for change.

In this context, the main actors of the knowledge ecosystem are all institutions involved in the process of creating, disseminating and using knowledge. These include scientists and educators, universities, research institutes, government, the public sector and business. The formation of a knowledge ecosystem is contingent upon the interaction of its constituent actors, as well as the establishment of a system of relationships and connections. The utilisation of cutting-edge digital technologies serves to create an enabling environment that is conducive to the formation of networks and platforms. The implementation of an ecosystem approach to the process of creating, disseminating and using knowledge is becoming an important foundation for a vector of societal development that is focused on improving the quality and safety of people's lives and innovations.

4. Conclusions

The conceptualisation of the knowledge ecosystem thus implies an understanding of it as a system of a consistent and sustainable process of creation, dissemination and use of knowledge at different levels. This process is carried out on the basis of sustainable development, self-regulation, environmental friendliness, synergy, and so forth. The evolution of the concept of "ecosystem" is based on the recognition of the interdependence of living and non-living systems, and the interconnectedness of economic, environmental, social, and technological development. The key role of knowledge in ensuring social progress is gaining new significance due to the revolutionary impact of the latest digital technologies on all aspects of modern society. New technologies, which are valuable knowledge in themselves and the result of the knowledge creation process, transform all processes and accelerate all transactions. The entire chain of knowledge creation, dissemination and use is gaining new meaning and opportunities.

The knowledge ecosystem is a complex and multidimensional phenomenon that can acquire different meanings depending on the level, nature and type of knowledge, forms of manifestation and target orientation. Each of these manifestations can be the subject of a separate study, which is confirmed by the review of scientific literature. The problem of forming a knowledge ecosystem environment at the level of a university, organisation, country, etc. still leaves much room for further analysis. The scientific interest is in identifying the key drivers and features of building effective knowledge ecosystems, studying

successful innovative practices of knowledge ecosystems formation at different levels. An important area of research is also identifying the features and prospects for

the development of network and platform ecosystems, as well as the benefits and challenges of using artificial intelligence.

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