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Kochetkov, D.

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Innovation: A state-of-the-art review and typology

Dmitry M. Kochetkov ^{a, b, *}^a Centre for Science and Technology Studies, Leiden University, Leiden, the Netherlands^b Peoples' Friendship University of Russia (RUDN University), Moscow, Russia

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Dedicated in loving memory to Loet Leydesdorff, who showed the Way

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ABSTRACT

Innovation is often an object of study in economics and management. However, the social and behavioral aspects of innovation acceptance are as important as the economics of product development. A significant portion of the literature considers innovation as a change in the way social actions are conducted, entailing a wide range of social, economic, behavioral, and institutional changes. Various approaches have given rise to the need for a typology. Sundbo (1998) divided innovation into three groups depending on the aspects of the phenomenon: theory of entrepreneurship, technological and social aspects, and strategic aspects. Adopting Sundbo's conceptual framework, this study supplemented and developed it based on recent literature that appeared after 1998. Moreover, this study added new directions at the second level of decomposition and the relationships between different aspects of innovation. In particular, this study analyzed phenomena such as open innovation, agile innovation, and "helix" models. Thus, this study developed a novel typology of innovation that expands the theoretical knowledge in this field. Based on these findings, this study proposed promising areas for future innovation studies.

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1. Introduction

Innovation is inherently an interdisciplinary object of study. Although innovation is most often studied within the framework of economics and management, it involves changes in behavior, that is, ways of implementing certain actions in society. Thus, the study of innovation extends to behavioral economics, sociology, and psychology. Innovation consists of not only the development of a new product or the commercialization of inventions but also humanitarian, social, and institutional biases. Considering consumer acceptance of new products, their habits and attitudes change. For services, the behavioral aspect is clear.

The concept of innovation was first proposed by the sociologist Gabriel Tarde, who proceeded from the thesis that social changes are made by people using new tools and patterns of behavior. Furthermore, the imitation process accelerates innovation diffusion. Thus, in Tarde's understanding, innovation is a complex social process that is beneficial for some social groups and disadvantageous for others (Tarde, 1999, 2001).

Joseph Schumpeter is considered the "father" of innovation theory. In addition, Schumpeter's views underwent significant changes. He connected the innovation process with the entrepreneur, changing the market and production processes through his active actions, and creating economic growth (Vanderburg, 2005). Furthermore, in his later work, Schumpeter (1939)

* Centre for Science and Technology Studies, Leiden University, Netherlands.

E-mail address: d.kochetkov@cwts.leidenuniv.nl.

emphasized the role of large companies in generating innovation to improve their competitive position, stimulating economic growth. The most important result of Schumpeter's work was the theoretical separation between invention and innovation. Entrepreneurs organize production and marketing using the inventions of others in their business activities. The task of the entrepreneur consists in changing the "rules of the game" in the market. Entrepreneurs assume all risks associated with innovation and, in return, receive entrepreneurial profit. Thus, entrepreneurs manifest themselves as actors who change the system and create a new structure. This definition of entrepreneurship dates back to [Say \(2008\)](#). However, this classic definition of entrepreneurship has fallen out of use, resulting in the term "entrepreneur" being associated exclusively with small businesses in some countries, such as Russia.

The classical innovation chain can be traced back to Schumpeter and includes a critical assessment of the current product/activity, invention, creative destruction, and commercialization/mass production. This chain appears to be the key to further development of innovation theory; thus, we need to determine these notions immediately.

- Invention implies the creation of new devices, processes, and combinations and a new understanding of existing devices. Inventions exist on the improvement continuum, from existing facilities to radical ones. Four types of inventions are recognized: scientific, technological, artistic, and cultural. Invention depends on cognitive processes, such as combination, analogy, and abstraction ([Welling, 2011](#)).
- Creative destruction represents the continuous process of the simultaneous creation of new enterprises and industries and destruction of the old ([Vanderburg, 2005](#)).
- Commercialization characterizes the transformation of technology or invention into a consumer product ([Li, 2017](#)). Nevertheless, the paths of such a transformation can be diverse. This includes direct technology transfer by the introduction into mass production of research results of R&D departments of companies, creation of small innovative enterprises by universities (SIE, start-up, spin-off) or innovative infrastructure, such as science parks and business incubators, and the indirect route through the creation of intellectual property with the subsequent licensing procedure ([Slaughter, 2010](#)).

In the 20th century, the theory of social change appeared in American sociology ([Zollschan and Hirsch, 1964](#)). At that time, the United States was dominated by a functional theory that viewed society as a system that fundamentally strived for a stable state. Without denying the possibility of change, this theory generated change while avoiding open conflicts between groups. Social change was considered an exception to this rule to a greater extent. The theory of social change may be considered a special discipline within the framework of sociology that focuses on the situations in which this phenomenon occurs ([Moore, 1967](#)). While social changes sometimes show a revolutionary character, the changes that occur more often are partial (incremental). Innovation appears to be a key concept in partially explaining social change ([LaPiere, 1965](#)). Innovation is created by people with deviant behaviors that upset the balance of the system. However, in the future, the system converges to equilibrium. Note that the issue of whether actors or structures represent the source of the changes continues to be a subject of discussion ([Giddens, 1984](#)).

Technological innovation has been considered from social and behavioral perspectives ([Rosenberg, 1976](#)). One of the main issues was whether technological changes caused social change or vice versa. [Ogburn \(1957\)](#) proposed the cultural lag theory, according to which technological innovations first change the material structures of a society, followed by cultural changes. Such technological determinism has caused criticism based on a thesis about the needs of society, which stimulate technological progress. This thesis was later perceived as a new interdisciplinary field, referred to as Science and Technology Studies (STS) ([Bijker et al., 1987](#)). The Actor Network Theory (ANT) considers material innovation a determinant of social change that complements social innovation ([Latour and Woolgar, 1979](#)). Regarding economic disciplines at that time, applied research was primarily aimed at research and development (R&D). Entrepreneurship has faded from the background.

Thus, a significant portion of the classical literature considers innovation as *a change in the way of conducting social action, entailing a wide range of social, economic, behavioral, and institutional changes*. This perspective coexists with the managerial and technological perspectives. The variety of approaches created the need to develop a typology by the end of the 20th century. This typology was proposed by [Sundbo \(1998\)](#). Since then, the theory of innovation as a field of scientific knowledge has actively developed. This study aimed to provide a snapshot of the current innovation research landscape and develop an updated typology based on recent developments. Based on a review of recent literature on innovation, this study developed a state-of-the-art typology of innovation. This typology has a two-level hierarchy and identifies the relationships between different approaches to innovation. The remainder of this paper is organized as follows. Section 2 presents a typology of innovation and explores the current state of the theory from three perspectives (entrepreneurial, technological, and strategic). Section 3 discusses our findings and suggests promising directions for future research. Among the promising areas of research, this study highlighted the contribution of innovation to the achievement of the Sustainable Development Goals (SDGs) and study of national contexts for the creation and utilization of innovation, where transnational corporations and local entrepreneurs meet. The latter topic can be explored within the framework of a multidisciplinary institutional perspective, which should provide a comprehensive answer to critical factors in the success of innovative development in a particular country.

2. Current state of the theory of innovation

Sundbo (1998) offered three perspectives on the current state of the theory of innovation.

- Theories based on entrepreneurship as a source of innovation.
- Technological and economic aspects with the objective represented by the economic effects of new technologies.
- A strategic aspect, considering innovation as a social process.

Accepting this conceptual scheme, this study noted that many theoretical directions are at the intersection of different aspects. Many of these appeared after 1998, when Sundbo's book was published. This study attempted to imagine the development of Sundbo's scheme by considering concepts that had already appeared in the 21st century (Fig. 1).

Entrepreneurship and the entrepreneurial university have been studied in relation to innovation systems and various types of “helix” concepts. The Triple Helix examines the interaction of business, government, and universities; that is, entrepreneurial universities are turning into key actors in the knowledge economy. Innovation systems and “helix” models are associated with a strategic aspect. Open and social innovation characterize the mechanism of interaction between universities, businesses, and society. Agile innovations discuss the innovation process from the perspective of organizational management. This study analyzed the current state of each of the above areas to highlight promising areas for the development of the innovation theory.

2.1. Entrepreneurship and innovation

The definition of entrepreneurship has been increasingly reduced to innovative activities. Simultaneously, research interests have shifted from the emergence of entrepreneurs to the process of innovation. A key question is whether intrinsic motivation or market opportunities are the driving forces for entrepreneurs. A fascinating collection of cases was compiled by Casson and Casson (2013). This collection includes both large companies and examples of individual success. However, there is no single answer to the question of the driving forces.

An entrepreneur does not exist in a vacuum. A modern entrepreneur exists in a network of professional and social links, whose demarcation lines are often difficult to draw. Networking provides access to financial, human, and technological resources. Thus, entrepreneurship implies a type of collective activity determined by the social structure. Although the incentive motives of the entrepreneur are individual in nature, the realization of their entrepreneurial potential depends on society and the institutions, in the sense that North (1990) attached to this term.

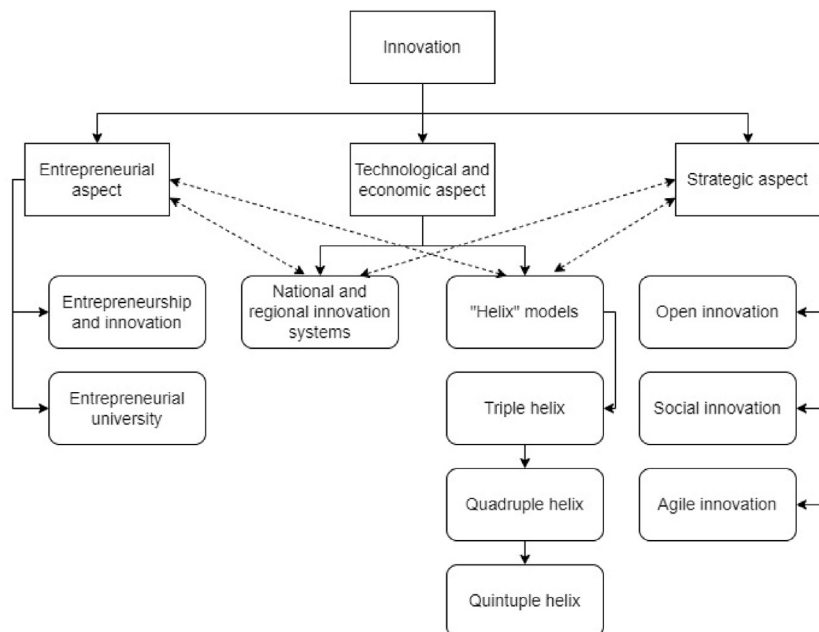


Fig. 1. Historical typology of the concepts of innovation.

In the 21st century, the research agenda for entrepreneurship and innovation has changed significantly. The digitization of industries and economies has transformed the existing value-creation chain. Nambisan et al. (2019) summarized the contributions of several studies and identify key topics related to digital innovation and entrepreneurship.

Openness. The nature and degree of openness facilitated by digital technologies in innovation and entrepreneurship in terms of who can participate (actors), what they can contribute (inputs), how they can contribute (processes), and what ends (outcomes).

Affordances. Action potential or possibilities offered by an object (e.g., digital technology) in relation to a specific user (or use context) in innovation and entrepreneurship.

Generativity. Capacity exhibited by digital technologies to produce unprompted change (through “blending” or recombination) by large, varied, unrelated, unaccredited and uncoordinated entities and actors.

Another issue that requires attention from researchers and policymakers is the compliance of entrepreneurship and innovation with SDGs. A considerable amount of literature investigated the relationship between entrepreneurship and sustainability (e.g., Cillo et al., 2019; George et al., 2021; Muñoz and Cohen, 2018; Volkmann et al., 2021). Entrepreneurship and innovation should contribute to sustainable economic growth. However, this is often not true. For example, Youssef et al. (2018) provided evidence that formal and informal entrepreneurship lead to environmental degradation in Africa.

2.2. Entrepreneurial university

Over the course of the 20th century, universities' involvement in the functioning of economic systems steadily increased. Universities moved from preparing students and publishing research results to contracting applied research, and many went further and created their own entrepreneurial ecosystems. Stanford, Massachusetts Institute of Technology, and Catholic University of Leuven in Europe are classic examples of entrepreneurial universities. The adoption of the knowledge economy concept has changed universities from passive participants in economic processes to key actors in the economic system. University accepts responsibility for social change and economic growth.

Literature on the problem of the phenomenon of the entrepreneurial university and its development began to appear in the 80s of the 20th century and the discussion continues until today (Gibb et al., 2013; Perkmann et al., 2013). Entrepreneurial universities transfer knowledge and directly create new enterprises. Most often, the phenomenon of entrepreneurial universities is examined in the context of a regional socioeconomic system (Carayannis and Campbell, 2009; Guerrero et al., 2014). Thus, the concept of an entrepreneurial university is related to regional innovation systems and the Triple Helix model. In Europe, universities' entrepreneurial activities are actively supported by the European Commission and Organization for Economic Co-operation and Development (EC-OECD, 2012). However, researchers have highlighted several challenges for entrepreneurial universities (Klofsten et al., 2018):

- The entrepreneurial ability of the university depends on dynamic organizational capabilities and is limited by environmental factors, as demonstrated in a study on the interconnection of knowledge commercialization and regional development strategies using the example of Tomsk and Novosibirsk regions (Kochetkov et al., 2017).
- An entrepreneurial university requires an appropriate way of thinking and organizational culture, and education should aim to achieve these goals.
- Setting clear goals, which will be used in the future as indicators to assess and clarify the true meaning of the concept of an entrepreneurial university for all employees and students, is important.

The subject of fierce debate to date involves the linearity and nonlinearity of universities' entrepreneurial activities. Should universities create innovative enterprises on their own or create conditions for their occurrence? Successful cases were observed in both cases. What factors affect the choice of strategy? Nevertheless, the success conditions for implementing a university's entrepreneurial strategy continue to be the focus of researchers.

2.3. National and regional innovation systems

From a theoretical point of view, the term “national innovation systems” is similar to “regional innovation systems”; however, there are significant differences in practical application discussed below. The concept of national innovation systems appeared almost simultaneously with the theory of economic growth (Freeman, 1995; 2002; Porter, 1990; Solow, 1956, 1994). Generally, national innovation systems aim to achieve long-term economic growth and create a sustainable national competitive advantage. The “new regionalists” are working around a similar theoretical outline (Huggins, 2000, 2003; Huggins et al., 2014; Malecki, 2007; Maskell, 1996, 1998). Consequently, an original direction emerged at the junction of national innovation systems, the theory of economic growth (especially in the Schumpeterian tradition) and the theory of innovation (Fagerberg and Srholec, 2008; Fagerberg et al., 2007; Jungmittag, 2011; Lee and Kim, 2009):

- National innovation systems can be considered as networks with certain functions and characteristics (Proksch et al., 2017; Wohlmuth, 2013);

- National innovation systems determine the quantity, quality and type of innovation activity (Arundel et al., 2007; Ebersberger et al., 2011; Tsai et al., 2009; Van de Vrande et al., 2010; Wang et al., 2012; Wonglimpiyarat, 2013; Yoon et al., 2015);
- National innovation systems ensure the interconnection of institutions and economic agents, as well as ensuring a balance between them (Bartels et al., 2012; Djeflat, 2009; Ivanova and Leydesdorff, 2014; Lai et al., 2014; Lee and Park, 2006; Varsakelis, 2006);
- National innovation systems identify key points for government intervention and policy optimization (Furman and Hayes, 2004; Solleiro and Castañón, 2005; Samara et al., 2012);
- National innovation systems absorb technological and structural changes (Antonelli, 2008; Castellacci and Natera, 2011; Hekkert et al., 2007).

The logical development of the concept of national innovation systems is a model of the hierarchy of levels of the innovation system, which proceeds from statements regarding the existence of a global innovation system (Fig. 2) (Asheim and Coenen, 2006; Hsu et al., 2014; Kenney, 2011; Kwakkel et al., 2014; Nill and Kemp, 2009; Sun and Liu, 2010; Van Lancker et al., 2016). In this scheme, we assume the existence of a synergistic effect that occurs in vertical and horizontal overlaps.

National innovation systems determine the flow of knowledge (including cross-border), technology transfer, commercialization of inventions and economic initiatives (Etzkowitz, 2002; Gomez et al., 2014; Lundvall, 1998; Niu, 2014; Paik et al., 2009). A separate “helix school” has grown out of this direction, which is one of the most comprehensive and widely used conceptual frameworks to date.

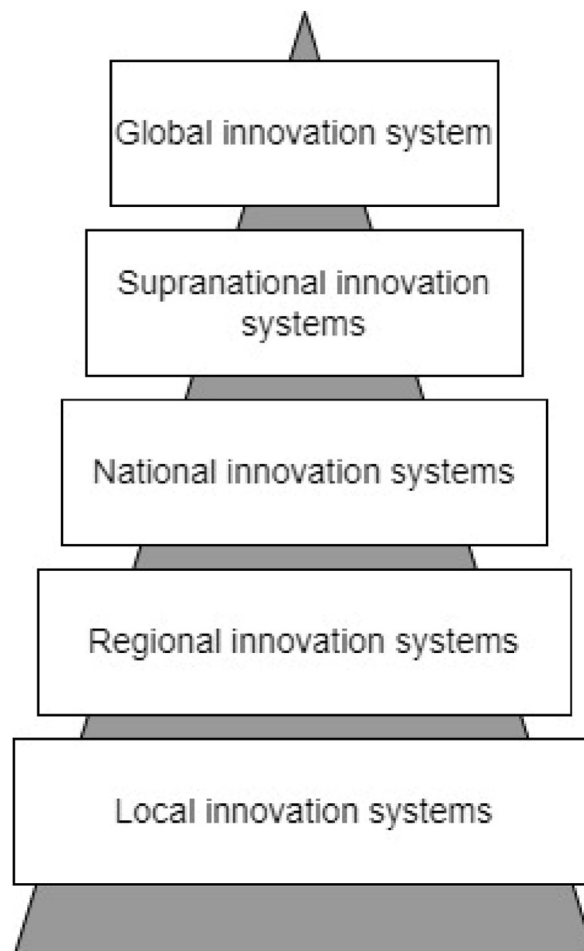


Fig. 2. Hierarchy of innovation systems.

2.4. “Helix” models

Although this group of concepts cannot be formally called a school, since 2000, there has been continuous theoretical and applied work on this issue. These studies are united around the problem of interactions between institutions within a territory (usually a region or country).

2.4.1. Triple Helix

The structural components of the Triple Helix model, which arose at the turn of the 20th and 21st centuries, were studied by [Etzkowitz \(1983, 1998\)](#) in the entrepreneurial university and were featured by [Leydesdorff and colleagues](#) in the field of evolutionary dynamics of science, technology, and innovation ([Leydesdorff and Van den Besselaar, 1994, 1998](#)).

The Triple Helix implies the interaction of universities, businesses, and governments in the innovation process. An important role is played not only by the participants themselves but also by the type of relationship between them. For instance, in the USSR and other socialist countries, a closed model existed, with the government playing the role of a supreme arbiter in the relationship between universities and industry (Mode 1) ([Etzkowitz and Leydesdorff, 2000](#)). This model is characterized by isolation from the outside world and lack of a market mechanism, leading to a low efficiency of the innovation process. Unfortunately, this model of “bureaucratic innovation” not only still exists in Russia but is actively stimulated by the government through direct financing mechanisms, tax incentives, and companies with government participation. Nevertheless, precedents for theoretical and applied research on innovative development models occurred. Such work has been conducted since the 1960s at the Faculty of Economics of St. Petersburg (Leningrad) University ([Molchanov, 2009](#)); however, due to the peculiarities of the socioeconomic system itself, these developments were applied, in part, only after 1991.

Mode 2 of the Triple Helix implies that the participants are independent of each other. Goods and services are acquired from each other on a contract basis for profit. Thus, Mode 2 goes back to the classics of economic theory, the “invisible hand” presented by Adam Smith ([Smith, 1806](#)). Nevertheless, as is known from further developments in economic science, classical political economists have not considered market failures. Therefore, this theoretical model almost never works in practice, and a market economy in the purest form does not exist.

Mode 3 of the Triple Helix implies the overlapping of institutional spheres. It is in the overlay areas that a synergistic effect is generated. This model is described as a “Triple Helix.”

For the functioning of the model, *endless transition* is extremely important, as it is an endless process of creative destruction ([Schumpeter, 1939](#)). This process stimulates a constant increase in the role of knowledge as a resource in the production and distribution ([Etzkowitz and Leydesdorff, 2000](#)).

[Etzkowitz \(2002\)](#) emphasized the exceptional role of the university and government in the period of shift in technological paradigms. University assumes an unusual role in creating forms and promoting regional development (complementing traditional education and basic research). Businesses are increasingly engaged in continuing training and research. The government, or regional government, provides support for initiatives through regulatory mechanisms, fiscal policy instruments, and direct funding. To some degree, this conceptual framework has influenced almost all regional development projects in the 21st century.

2.4.2. Quadruple and quintuple helices

[Carayannis and Campbell \(2009\)](#) expanded the Triple Helix model by proposing a Quadruple Helix. In addition to universities, businesses, and governments, the Quadruple Helix includes institutions of civil society. Carayannis and Campbell defined the Quadruple Helix as “public” (based on the media and culture) and “civil society”. The public is a system-forming element in the theoretical framework of the knowledge economy and knowledge-based society as the main consumer of knowledge. Knowledge flow permeates all areas of public life. An equally important component is represented by the “knowledge culture,” which includes values and lifestyles, multiculturalism and creativity, media, universities, and multilevel innovation systems (local, regional, national, and global) ([Carayannis and Pirzadeh, 2014](#)). Together these form the “Creative Knowledge Environment” (CSE), that is, a social environment conducive to the creation of new knowledge and innovation. This concept correlates with the institutional environment, particularly the degree of economic freedom in the country and the type of social contract.

While the Quadruple Helix contextualizes the Triple Helix model in social environments, the Quintuple Helix introduces the natural context of innovation systems. In full accordance with the interdisciplinary nature of modern scientific knowledge, the Quintuple Helix aims to create and develop conditions for the sustainable development of society, economy, and democracy in the medium and long term. [Carayannis and Campbell \(2010\)](#) introduced a very important concept of “social ecology,” representing a transdisciplinary field of research for a comprehensive solution to global problems. Thus, while the first three helices represent the institutional spheres of actors in the innovative development of society, the quadruple and quintuple helices contextualize their interactions in social and natural environments.

2.5. Strategic aspect

Open innovation is a new strategic paradigm. This concept was introduced by [Chesbrough \(2006\)](#). [Chesbrough and Bogers \(2014\)](#) defined open innovation as a distributed process based on a purposefully controlled flow of knowledge beyond

organizational boundaries. The concept demonstrates the way firms can organize inbound and outbound knowledge flows (Enkel et al., 2009). Recently, open innovation has become a popular research topic (Dahlander and Gann, 2010). Modern research in this field is spreading to new areas and objects, including small and medium enterprises, nonprofit organizations, and politics (Vanhaverbeke et al., 2014).

The popularity of open innovation is based on the fundamental idea of the distributed nature of innovative knowledge in the economy (Hayek, 2012), in other words, most smart people work elsewhere. Factors that stimulate innovation include increased labor mobility, increased access of start-ups to venture, and the rapid development of information and communication technologies, including social networks (Chesbrough, 2003). In the coming decades, open innovation will play an increasingly significant role in developed economies. Bogers et al. (2018) highlighted the trends and challenges in the development of this concept.

- Further digitalization of society and the economy, and the development of new technologies from blockchain to genome editing.
- Combining open innovation with sustainable development goals in the international arena.
- Affirmation of China as an innovative global leader.
- New sources of financing innovation, primarily crowdsourcing.

In addition, open innovation raises many organizational and legal issues (Felin and Zenger, 2014), including the organization of communication channels for modelling inbound and outbound knowledge flows and the division of intellectual property rights for created objects.

Social innovation is a relatively new concept that aims to meet societal needs. Although it is sometimes impossible to clearly distinguish between social and non-social innovations, some schools, such as ANT, consider them to be the foundation of social change. Agile innovation is the youngest term used in this study. It originates from software development. Agility allows companies to respond to market changes quicker than traditional “waterfall” development.

3. Conclusions

This study developed a novel historical typology of theoretical approaches to innovation. The innovation phenomenon is multidisciplinary. This implies not so much the creation and commercialization of a product as a change in social patterns of behavior. Therefore, innovation has historically been studied not only in the framework of economic theory and management but also in the framework of sociology, psychology, and behavioral economics. The innovation process involves forming new public institutions. This study developed a novel scheme based on the evolution of theoretical approaches to innovation. Modern theory considers innovation from the point of view of various aspects (entrepreneurial, technological, economic, and strategic). This study updated the conceptual framework presented by Sundbo (1998) based on recent research in three areas: entrepreneurial, technological and economic, and strategic dimensions. These three perspectives are closely related.

One of the most accepted concepts at the intersection is the concept of a Triple Helix, with further modifications to quadruple and quintuple helices. Thus, while the first three helices represent the institutional spheres of actors in the innovative development of society, the quadruple and quintuple helices contextualize their interactions in social and natural environments. However, Smith and Leydesdorff (2022a) argued that higher-order helices are part of policy discourse, while the Triple Helix is part of the academic research agenda. Furthermore, when a number of elements is higher than three, the interactions can be decomposed as a set of triads (Smith and Leydesdorff, 2022b).

The digital transformation of economies and societies has significantly changed the innovation landscape and research agenda. Moreover, many researchers and policymakers are concerned about how innovation will contribute to the SDGs; thus, innovation studies go far beyond economic, technological, and management research. Innovation plays a significant role in the development of Society 5.0, which is a vision of a future society guided by scientific and technological innovation, aiming to create a human-centered, super-smart, and lean society (Huang et al., 2022). This concept is closely related to Industry 5.0, which assumes that new technologies should give society more than just economic growth. The roles of innovation and entrepreneurship in the development of public institutions and a better society are promising directions for future research.

Another issue to be tackled in the future is that most innovation theories and concepts (if not all) were formulated in developed countries (Hang and Chen, 2021). Emerging markets, where multinational companies and local entrepreneurs meet, pose significant challenges to innovation development and commercialization. Thus, studies of national contexts and their impact on innovation and entrepreneurship in a particular country are an important part of academic and policy discourse.

In the latter case, it is promising to examine innovation within an institutional theory framework. Traditionally, the efficient production of innovation has been associated with developed democracy (e.g., Helms, 2020; Popper, 2005, 2012). However, Gao et al. (2017) have not supported this hypothesis empirically. This study was refuted by Wang et al. (2021), who also tested a number of hypotheses about innovation success factors depending on the type of democracy and autocracy as well as the level of GDP. Therefore, one can argue that the empirical results are partially contradictory. The shift in the center of innovation development from the Global North to the Global South will further weaken the correlation between

democracy-innovation-growth and development. Moreover, we still do not have a comprehensive answer to the question of what the key factors in the success of a national or regional innovation system are. The institutional configuration model that considers a unique set of institutions specific to a given territory (region or country) can help answer this question (Frolov, 2016; Popov et al., 2017; Solodilova et al., 2015). Special attention is required when institutions aimed at creating a fertile environment for innovation do not work at all or do not work as intended. In the latter case, we address institutional dysfunction (Prakash and Potoski, 2016). It must be noted that the institutional theory is multidisciplinary and corresponds to innovation as an object of study.

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Declaration of competing interest

The author(s) declare no conflict of interest.

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