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# INNOVATION PROCESSES: FROM LINEAR MODELS TO ARTIFICIAL INTELLIGENCE

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## ABSTRACT

This study aims to map scientific publications, intellectual structure and research trends in the development of innovation process models and to characterise and compare them. Specifically, to identify the innovation process models and their characteristics, comparative analysis of the models, and predict the direction of development. A hybrid method was used, which involved many years of in-depth literature monitoring and comparative analysis based on a set of parameters developed by the authors. The results made it possible to identify and classify 15 various theoretical models of the innovation process (from M1 — linear to M15 with the AI contribution) development through categorisation according to five main features: C1 — complexity, C2 — openness, C3 — the role of technology, C4 — the participation of the market/users, and C5 — the form of presentation. This study identifies, explores, analyses and summarises the main ideas of innovation processes by identifying their models and characterising those specifics that can ensure international standards of excellence. The study provides an objective view of the existing innovation process models and the relevant studies that can guide managers in their decision-making innovation processes. This study is a first attempt at unveiling the evolution of knowledge in the field of existing innovation processes and their characteristics and comparative analysis. The presented models of innovation processes should constitute an indication for practitioners who can choose a model to be used in the economic practice of their organisation.

## KEY WORDS

**innovation, innovation process model, open innovation, comparative analysis, artificial intelligence**

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## INTRODUCTION

Innovation is the basis of competitiveness, which is why it is constantly researched by practitioners and theoreticians in technical, medical and economic sci-

ences. Innovations drive the economic development of companies and whole economies, so the methods for creating and implementing innovations in organisations regularly constitute a subject of scientific analyses. For this reason, it is important to advance research on innovation process models for the development of economic and management sciences and,

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above all, for business practice, as it shows the potential for implementing innovations in companies.

Schumpeter (1932) noticed and described the importance of innovation first; his concept is used by other researchers (Drucker, 1985; Ciborowski, 2003; Chesbrough, 2003a; Poblete, 2018; Winkler et al., 2022) and institutions studying innovation (World Bank, Organization for Economic Cooperation and Development — OECD, Eurostat, national and regional statistical offices). Searching for the most optimal methods (models) for introducing innovations is an ever-present challenge. Contesting innovative processes is, therefore, a big challenge for researchers who want to trace the development of innovative process models, starting from the initial linear concepts (Daft, 1978) and ending with processes co-created or created by artificial intelligence (AI) (Kuziar et al., 2023).

The purpose of this study is to provide an overview of innovation process models, characterise and compare them, and attempt to determine the directions of their development. This article constitutes a theoretical analysis based on collected proposals for innovation process models found in economic literature, which were characterised and subjected to an original evaluation designed by the author, which involved identifying their features and comparing them. The study culminates in an attempt to determine the direction in which innovation theory is heading in relation to formulated innovation process models. This means that the study, despite its qualitative nature, also has a practical aspect, as it allows for comparing various solutions and the possibilities for using them in business practice.

## 1. REVIEW OF LITERATURE ON INNOVATION IN THE ECONOMY

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The issue of innovation and its improvement methods is widely described in economic literature. This stems from the fact that introducing innovations in the economy is considered a primary factor of development at the microeconomic level, which concerns a single organisation (company), and the macroeconomic level, i.e., which relates to the economy of a region, country or entire Europe.

The importance of innovation in the economy was noticed as early as the 1930s. Schumpeter (1932) should be considered the pioneer of the theory of innovation as he realised that changes resulting from

constant adjustments in the economy do not lead to new phenomena or development, as economic development is characterised by “new combinations”, which we now call innovations. The definition of innovation proposed by Schumpeter seems still valid and is expressed by the introduction of new goods into production or the improvement of existing ones, the introduction of new or improved production technology, the application of a new sales or purchase method, the opening of a new market for the sale or distribution of production and supply, the use of new raw materials or semi-finished products and the introduction of changes in the organisation of production. Researchers who continue Schumpeter’s ideas include Rosenberg (1994), Drucker (1985), Grudzewski and Hejduk (2008), Poblete (2018), Gomułka (1998), Szymańska (2020), and Kuziar et al. (2023). In the spectrum of interests of economists studying innovation, two main directions of research — macroeconomic and microeconomic — can be distinguished, encompassing several trends that represent both approaches, among which innovation policy (macroeconomics) and innovation in business (microeconomics and organisational management) are the most prominent. Special attention is given to innovation policy at the national and macroregional (e.g., European) levels (Furman et al., 2002; Grupp & Mogege, 2004), with a particular emphasis on the economic determinants of innovation (Hollenstein, 2003; Gault, 2010). On the other hand, international teams of researchers explore the microeconomic approach, focusing on the issue of innovation in manufacturing companies (Björkdahl et al., 2022; Tuominen et al., 2004; Perunovic & Christiansen, 2006). An important research trend is the effect of technological advances and R&D expenditure on innovation processes in companies (Calantone et al., 2002; Garcia & Calantone, 2002; Agramunt & Berbel-Pineda, 2018; Aw et al., 2011). A relatively recent direction for the analyses conducted by economists is the study of innovation in economy in the sustainable development context (Abreu et al., 2023) or using a sectoral approach (Garcia & Hollanders, 2009; Szymańska, 2021; Berbel-Pineda & Ramírez-Hurtado, 2012; Panfiluk & Szymańska, 2017; Alzyoud et al., 2024), with a particular emphasis on small and medium-sized enterprises (Keizer et al., 2002; Frel, 2003). Of note is research on innovation in companies in the tourism industry (Hjalager, 2010; Szymańska, 2013), which constitutes an example of new scientific challenges. Consumer innovation should also be mentioned as a new research trend

(Roehrich, 2004). In addition to these fields, there are numerous attempts to search for innovation in various areas of economic and social activity (Deshpande & Farley, 2004; Knudsen & Roman, 2004). Innovations are also considered in terms of their classification, considering the division into product (2021) and business (OECD, 2018) innovations. A specific kind of summary presenting innovation management models is the review article by Sossaa et al. (2019). A review of articles, selected according to the keywords “innovation management” and “model”, published between 1985 and 2017, yielded 73 specialised documents. A total of 47 articles, 23 documents in proceedings and three book chapters were collected, which led the authors to identify commonalities in literature and distinguish six different patterns for innovation management models. The review focused on the classification of authors, theoretical framework, methodology and country. As a result of their search, the authors presented four Innovation Management Models (IMMs); however, no innovation process models were offered.

In summary, it should be noted that the last few decades of the 20th century, and especially the early 21st century, brought about intensive growth of research, which led to a significant broadening of the scope of innovation and theoretical analyses. Said scope includes studies by international organisations, among which it is worth noting the OECD programme (2021) concerning research on innovation, which provided an impetus for a large-scale search for data interpretations, theoretical generalisations and indications for socio-economic policy and business activity.

## 2. REVIEW OF LITERATURE ON INNOVATION PROCESS MODELS IN THE ECONOMY

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Intensified research of innovation processes led to various concepts and theoretical models being created. In the early 1990s, Rothwell (1992) attempted to systematise and describe innovation processes, identifying their four generations, i.e., the push, pull and parallel processes as linear processes and the coupling process, which is not linear. At the beginning of the current century (millennium), Ahmed (2000) distinguished six generations of the innovation concept. Another important publication is the article by Dahan et al. (2011). Over the last two decades, the number of

innovation process models proposed in scientific studies has doubled, and the author of the article has identified 15 models.

It should be noted that the concept initiated by Schumpeter in 1932 did not attract much interest at first, and only the translation of his work into English paved the way for the theory of innovation. The beginnings of the dynamic development of the theory of innovation and innovation process models date back to the 1950s when two concepts were born, which should be considered the starting point for further research, namely the “pushed by science” and “stimulated by the market” linear models. In the “pushed by science” model, the initial impetus is basic research, which is conducted to discover new scientific patterns, mechanisms or principles and constitutes the basis for formulating the laws of science. This research stimulates applied research, dealing with the practical application of the gained knowledge. Basic and applied research is commonly called “research and development” (R&D) (Bogdanienko, 1998). This model is also called as the supply model (Urbaniak, 2004). Stawasz (1999) pointed out that this innovation process model was widely used until the mid-1960s. An example is the innovation process proposed by Pomykalski (2001), which encompasses concept, concept analysis, operating model, prototype and its refinement, design and assembly of a production prototype, launch of a short series, refinement, and launch of full-scale production. The final stage is commercialisation, a term derived from Latin *commercialis* — pertaining to commerce — and means basing an activity on commercial principles (Chociłowska, 1991).

The second linear innovation process model is “stimulated (pulled) by the market” and is also called the demand model (Urbaniak, 2004). In the 1970s, Daft (1978) identified customer needs as the initial impetus in the innovation process and proposed five main stages, with consumer needs as the initial impetus and implementation of innovation as the final element. A more expansive linear innovation process “pulled” by demand was presented by McGowan (1996), who emphasised the need to generate innovative ideas in multiple areas of activity within the process.

A non-linear approach to innovation processes was initiated by Kline (1985), who demonstrated that the innovation process is much more complex and involves interdependencies and feedback between its phases (Butryn, 2004), while individual elements stem from feedback between science, the market and

business. Such an interactive process is characterised by the occurrence of feedback, which is a mechanism of direct or indirect influence of changes at the outputs of the given model on the state at its inputs and is based on cooperation between consumers and various teams within a company: marketing, commercial, design, supply, and production (Kline & Rosenberg, 1986; Szymańska, 2009).

The coupling model concept initiated a new phase in developing the theory of innovation, which led to the creation of further models. IT systems, defined as a set of interconnected elements whose function is to process data using computer technology related to the computerisation of organisations and innovation processes, should be considered the next stage of development of the theory of innovation. Today, IT systems (especially the Internet) are indispensable in the activities of organisations (Rutkowski, 2007) and accompany further innovation processes. The computerisation of society and the economy made it possible to include resources outside an organisation in innovation processes.

The early 21st century saw the emergence of “self-learning” systems and further breakthrough concepts (Pralhad & Krishnan, 2008). Developing an integrated innovation system, which includes at least two sub-systems aimed at optimising external and internal processes, should be considered the next stage (Management..., 2000). Another proposal for innovation process models is “self-learning” models, which strongly emphasise using knowledge in business (Baruk, 2006).

The open innovation concept by Chesbrough (2003a) proved to be a breakthrough in the perception of innovation processes. The open innovation model is based on the belief that organisations should search for ideas and ways to capture the market outside instead of focusing on their resources, thus moving a part of the innovation process beyond the organisation. That way, the boundaries of an organisation become “fluid”, and the outcome of the process may result in innovation in existing and new markets. Chesbrough found many continuators, which resulted in numerous studies and implementations, which is evidenced by, among others, the report *United We Stand: Open Service Innovation Policy Schemes: An International Policy Scan and Two Case Studies — London and Helsinki Metropolitan Areas* (Bos et al., 2010). The report’s authors assessed the openness of Finland’s and the UK’s innovation policies. Results show that innovation policy should place more emphasis on openness and supporting innova-

tion, especially in the services sector. Organisations with a task to support open innovation processes have also been established (Wanhaverbeke, 2008). The distributed innovation model (Hobcraft, 2011) can be seen as an extension of the open innovation concept. It focuses on open innovation inside and outside a company with an intensive flow of knowledge. In this instance, it is necessary to think about innovation as a process involving a large group of employees supported by external entities. A study on the implementation and effectiveness of this model was conducted on a group of over 460 companies providing medical tourism services in Poland. Results proved highly promising and showed that applying such a model leads to the highest (compared to other models) level of innovation at the studied entities (Szymańska, 2017a; Szymańska et al., 2017). Björkdahl et al. (2022) explained the business model innovation processes in industrial firms (qualitative research in character), drawing on three case studies of leading business-to-business firms shifting from product-based to service-based business models. A qualitative empirical analysis regarding the innovation process of the business model was also conducted by Laudien and Daxböck (2017). However, in the case of qualitative research, it is difficult to objectively verify the results. Business models in the context of innovation are discussed based on Canvas (Adamik et al., 2023). In this case, the innovation process consists of nine basic elements: customer segments, the value offered to customers, sales and service channels, nature of customer relationships, key processes, resources, partnerships, revenue structure, and cost structure (Adamik et al., p. 201). Innovation processes are also examined in the context of a single industry, such as spa and wellness (Panfiluk et al., 2016).

The User-Driven Innovation (UDI) concept is a continuation and deepening of the open innovation concept. It is based on the assumption that consumers (users) should increasingly strongly influence commercial offerings, including participation in creating products and services they purchase (Szymańska, 2017b). UDI can be defined as “the process of drawing on user knowledge to develop new products, services and concepts, which is based on a genuine understanding of user needs and systematic involvement of users in the process of development of businesses, especially in terms of implemented innovations” (Ostrowska, 2012; Selden & MacMilan, 2006).

One more recent proposal is the three-dimensional innovation model by Lindgren and Taran

(2011), which has an element of openness in an organisation's innovation process and marks this openness on three different levels. The innovation process generates higher value by creating an effective knowledge flow system inside and outside the organisation. Hobcraft (2013a; 2013b) proposed the “three-horizon model for innovation”, which is based on the “three-dimensional model” idea by Lindgren and Taran (2011). It depicts a process where organisations (companies) move through horizons:

- horizon one — the current focus on business;
- horizon two — more closely linked to emerging business opportunities;
- horizon three — development towards a completely new company with the potential to disrupt the status quo.

The process requires various tools and ways of thinking, which should be based on observation and action (horizon one), adaptation of the framework for thinking and searching for solutions (horizon two), and evolutionary and future-oriented solutions (horizon three).

The most recent innovation process concepts are mostly practical. Those created in recent years are open and draw on the latest technological advancements, including Artificial Intelligence (AI). They also consider the principles of sustainable development, especially its environmental aspect. Another feature of these models is their global nature. Two models can be an example: the Enterprise Management Innovation Ecosystem (Grid Report, 2020) and the EFQM. The first is based on using special software featuring AI to create and commercialise innovations. An optimal innovation process model is generated after inputting the appropriate data into the software. G2 named Qmarkets the leader in software for managing innovation ideas, comparing it to Brightidea, Compass, Wazoku, Ideanote,

Ideascale, Innocentive, Planview Spigit, Rever, and Sideways.

In turn, the guiding principles of the EFQM model help organisations consider how they support the UN Global Compact (2000) initiative and the 17 Sustainable Development Goals specified by the UN, as well as how it addresses the megatrends that are most likely to impact its ecosystem. The EFQM innovation lens focuses on actions, processes and culture, which stimulate innovations and help them blossom. It represents a broad view of innovation and aims to measure tangible business effects in relation to the goals of an organisation and the degree to which they are achieved (fulfilled).

A typically financial approach to innovation processes is represented by Raedersdorf-Bollinger (2020), who discusses the forms of managerial control. The author surveyed 169 companies, indicating their varied methods for controlling innovation processes.

The subdiscipline of the theory of innovation and, especially, innovation process models has notable challenges: it is highly dynamic, with researchers and practitioners creating increasingly advanced concepts, from the initial simple linear models to the more complex ones, considering the latest technological advancements. A comparison of these models is presented in the following chapters.

### 3. RESEARCH METHODS

Aiming to realise the goal, a hybrid method was used, which involved many years of in-depth literature monitoring and the use of comparative analysis based on a set of parameters developed by the authors. The study identified and characterised 15 different

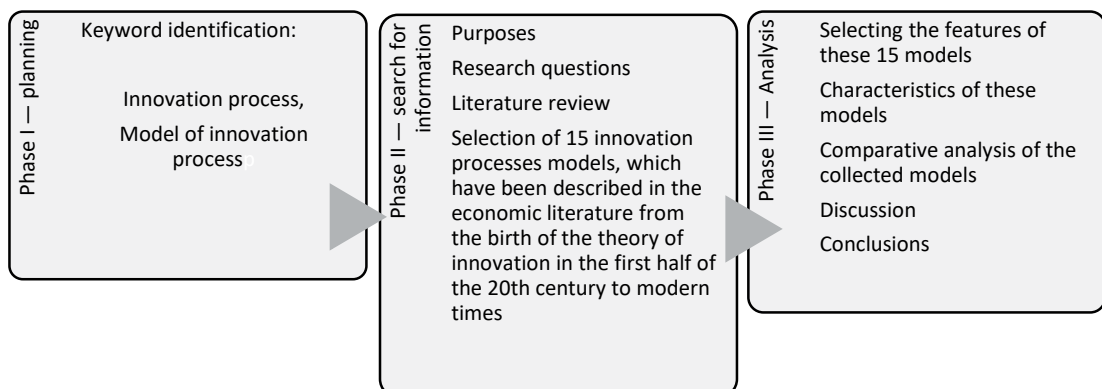


Fig. 1. Phases of the research process

innovation process models found in economic literature published between the 1950s and the present (2023). Notably, the list is open-ended, as research on innovation is intensive, especially in light of recent events that significantly impact the global economy and our everyday lives, namely, the coronavirus pandemic and the war in Ukraine started by Russia.

This study is based on the current knowledge of innovation process models in the economy. The literature review involved systematically following the new concepts in this scope over many years, starting from books by the father of the theory of innovation, Schumpeter, and ending with resources of the specialist economic scientific journals found in the Scopus and ELSVIER databases. Aiming to achieve the formulated research goal, the research process was carried out in three phases, presented in Fig. 1.

The first phase focused on research issues, which involved identifying the concepts of innovation process models and formulating keywords. The next phase observed and explored the economic literature dealing with the concepts of innovation process models developed by economists over the years during the advancement of the theory of innovation from 1932, when Schumpeter's monograph was published, until 2023. The first study phase aimed to identify the concepts of innovation process models and characterise them. The phase resulted in the identification of 15 models, which in the second phase were ordered and described in a table, considering their key features, and then, in the third phase, subjected to comparative analysis, which constituted the basis for discussion and the subsequent formulation of study conclusions and recommendations for economic theory and practice.

According to Stachak (2006), a comparative analysis comprises mental analytical activities that involve distinguishing objects, their features, and relationships. Comparative analysis methods concern several important issues and are carried out in various ways. According to Konecki (2000), a comparative method can be open and closed. In an open comparison, the scope of empirical cases for comparison is not limited a priori, and the cases are selected as the pattern for interpretation emerges throughout the intellectual process called an analysis. On the other hand, a comparison closed a priori involves selecting the studied subjects (groups) before the study and analysis to give them a defined, stable structure. According to Szarucki (2010), this method entails analysing the studied objects and phenomena using appropriate criteria to ascertain the same, simi-

lar or different degrees of intensity of the studied features. The comparative analysis method used in this study is closed (as the analysis was conducted after the models had been identified). It involves identifying and comparing features which characterise individual models. The study should, therefore, identify the similarities and differences between individual concepts — innovation process models.

During the study, the following features of the innovation process models subjected to the comparative analysis were identified:

- C1 — complexity. i.e., the number of components of the model;
- C2 — openness to the environment (micro or macro), wherein the microenvironment is specific to a business or the immediate location or sector in which it operates, while the macroenvironment refers to broader factors that can affect a business. Examples of such broader factors include demographic, environmental, political, economic, socio-cultural, and technological factors (Singh et al., 2021);
- C3 — the role of technology in the innovation process;
- C4 — the role (participation) of the market/users;
- C5 — the possibility of presentation in a graphical form.

The indicated factors were used to perform a subjective original evaluation designed by the author based on data found in publications of the presented concepts or available scientific literature. The study results are presented in the following chapter.

## 4. RESEARCH RESULTS: COMPARATIVE ANALYSIS OF INNOVATION PROCESS MODELS

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Looking at the concepts within the scope of the theory of innovation, the author identified fifteen intersecting stages of its development. An attempt at a graphical presentation is shown in Fig. 2.

The figure shows the development dynamics of the theory of innovation in relation to subsequent concepts (models) of innovation processes (cf. Szymańska, 2013). Schumpeter's theory (1932) did not attract much interest until it was translated into English. Its dynamic development dates back to the 1950s, when two concepts were formulated and

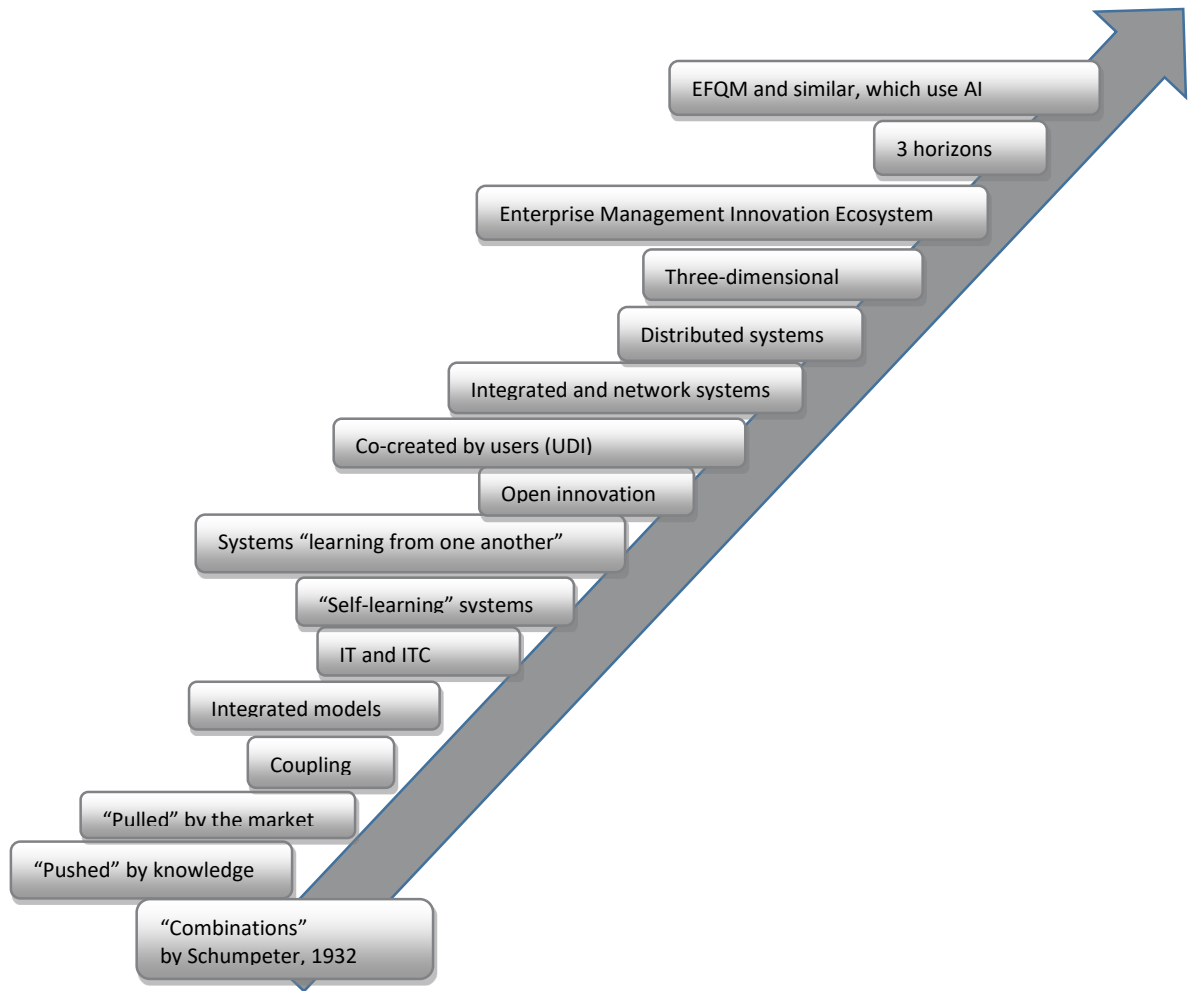


Fig. 2. Development of the innovation concept from Schumpeter's theory to concepts that use AI

should be considered the starting point for further research, i.e., the linear innovation process models.

Following the main goal of the study, individual models were characterised, and five detailed features of these models were identified (Table 1).

In general, the focus is on two basic groups of innovation process models. The first group consists of linear models, which include the three initial ones, i.e., "pushed by learning", "pulled by the market", and "parallel" (M1, M2, and M3). The remaining models are complex, as considered in the table above (feature C.1 — complexity). Furthermore, as the complexity of the models generally increases, so does their openness or the inclusion of entities from outside the organisation in the innovation process (feature C2 — openness). A particular intensification of this feature can be seen since Chesbrough's publication (2003b) and dissemination of the concept of open innovation (M8), which the author highlighted in the graphical presentation of the process (Feature 5), by

marking the smoothness of the organisation's boundaries with a dashed line. It is important to recognise that each subsequent study (M9–M15) has this feature to a greater or lesser extent. A model that should also be considered groundbreaking is the IT model (M6), where the main importance in the innovation process is given to new technologies. The IT model accompanies all subsequent models (M7–M15) and, in the case of model M14, even forms the basis of the construct in the form of artificial intelligence (AI) (Feature C3 — the role of technology). The three horizons model (M13) is noteworthy due to its high level of abstraction and its emphasis on creativity in the innovation process through its proposal to map different ways of thinking and possible innovation options against changing horizons. Using this approach, it is possible, according to Hobcraft (2021), to shape innovation in different ways, as innovation is constantly evolving and using the three horizons concept allows for accelerating innovation.

Tab. 1. Characteristics and comparative analysis of innovation process models

No.	MODEL	MODEL CHARACTERISTICS	C1 COMPLEXITY	C2 OPENNESS	C3 THE ROLE OF TECHNOLOGY	C4 PARTICIPATION OF THE MARKET/ OR USERS	C5 GRAPHICAL/ DESCRIPTIVE FORM	ORIGINATOR/ SELECTED SOURCE
M1	"Pushed" by science/supply	Primarily, a linear model of an innovation process "pushed" by science uses research; purchasing licences, ready solutions; copying the actions of competitors; acquiring businesses	Linear – simple	Closed process	No indications	None	Yes	Török et al. (2018)
M2	"Pulled" by the market	A linear model of an innovation process "pulled" by the market, considers market analysis and cooperation with key buyers	Linear – simple	Closed process	No indications	Market research	Yes	Daft (1978)
M3	Parallel (demand/supply)	Internal integration of business and cooperation with suppliers and customers in the supply chain; the focus is placed on relationships and alliances, which intertwine and are interconnected. It ensures an appropriate supply of innovation shaped by the demand for it from the market.	Linear – complex	Partially open	Some participation of new technologies	No	No	Kozioł (2008)
M4	Coupling	Interactive models where the relationships between individual elements stem from feedback between science, the market and the individual. There is an exchange of information with participants in the value chain, which includes customers and suppliers	Non-linear – complex	Closed	No indications	Partial participation in the form of market research	Yes	Kline (1985)
M5	Integrated	They combine at least two subsystems of the innovation process system	Complex	Limited to two systems	No indications	Partially		<i>Management System Integration: A Guide</i> (2000)
M6	IT	Related to information technology. IT systems accompany all subsequent concepts of innovation models.	Simple – based on modern technologies		Direct dependence (the main element of the process)	No	No	Prahalad and Krishnan (2008)
M7	Self-learning	Characterised by a strong emphasis on the use of knowledge in business and sustainable care for technology and intellectual resource needs. Focus on knowledge management and learning supported by an electronic toolkit facilitating ongoing information transfer and decision-making. Planning and arranging organisational systems so that they make it possible to create new knowledge, externalise the creativity of employees and managers, store knowledge, discover knowledge, disseminate knowledge and apply and re-use knowledge.	Depending on the accepted definition approach	Rather closed	To a small extent; the main value is human resources as well as individual and group knowledge	None	No	Baruk (2006)
M8	Open innovation	Cooperation with various external entities during innovation processes considers organised use of open information sources; purchasing research institutions; and selling licences (providing solutions).	Relatively simple	Open by definition	Some participation of new technologies	Yes	Yes	Chesbrough (2003a)
M9	Network systems	Integrated systems are based on network-flexible relationships and a response system linked to the consumer, and constant innovation. They are based on using specialised software in contacts with purchasers.	Complex	Open	Some participation of new technologies	Yes	No – separate illustrations for integrated and network systems	<i>Management System Integration: A Guide</i> (2000)



M10	User-driven innovation	Co-creation of innovation by customers/patients who constantly intervene in the process.	Complex	Open	Significant participation of new technologies	Yes — leading role of the users	Attempt at a graphical presentation: Szymańska (2016)	Rosted (2005)
M11	Three-dimensional innovation model	It focuses on open innovation inside and outside an organisation, occurring on three different levels; it can be considered one of the most recent proposals. The innovation process is carried out (generates higher value) through the creation of an effective knowledge flow system (inside and outside the organisation).	Hard to say	Open	Yes	No information	Yes — presented on converging axes; model presents three areas (axes): radicality, scope — from global (unique) innovation to novelty for a particular business, complexity	Lindgren and Taran (2011)
M12	Distributed innovation model	Innovation is created by entities inside and outside an organisation. Extension of the open innovation concept requires and an intensive flow of knowledge	Complex	Open	Some participation of new technologies	Yes	No graphic representations were found in relation to innovation	Tang et al. (2022)
M13	Three horizons	Companies move from the first horizon, which is the current focus on the business, through a second horizon that is more related to emerging business opportunities, to a third horizon, moving towards a completely new company with the potential to disrupt the status quo. Foresight into the future and creativity in predicting the future play a major role.	Complex	Open	Significant contribution of new technologies and artificial intelligence	No information	Descriptive formula, simplified graphical representation	Hobcraft (2013); Hobcraft (2015)
M14	Enterprise Management Innovation Ecosystem	Includes participation of stakeholders....	Open with a global character	Open	This is based on the use of special software with artificial intelligence to create and commercialise innovations Your Management Innovation System, Qmarkets	Yes	Yes	<i>Your Management Innovation System</i> (2023)
M15	EFQM model	EFQM model guiding principles help any organisation consider how it supports the United Nations Global Compact (2000), the United Nations 17 Sustainable Development Goals and how it addresses the Megatrends most likely to impact its ecosystem.	Complex	Partially open	Basic – leading	Minor	Yes EFQM	<i>Innovation</i> (2023)

The importance of graphic representation is a leading element in the presentation of selected innovation processes. This is particularly relevant for the three-dimensional model (M11). The visualisation of the model is presented on converging axes and creates a three-dimensional space that helps to qualify innovations in a business model presenting three areas (axes):

- radicality of the innovation (Is it new?): implementable or radical;
- range from global (unique) innovation to novelty for a particular company;
- complexity, i.e., the number of components changed simultaneously.

One of the main features distinguishing contemporary emerging models is the role of the market, or

users, in the innovation process. The importance of demand was already noted in the first models (M2), but the UDI model seems to be the closest to this concept as it assumes user participation in the innovation process practically at every stage (M10), assuming constant modification of the product with their participation. Moreover, the concept of open innovation also considers the role of the market, although not to such a significant extent as UDI and mainly at the stage of results, i.e., in the form of a twofold effect of the process: as an innovation appearing on the existing market and an innovation entering a new market.

All of the discussed features are included in the context of the individual models. However, they have varying degrees of intensity and are not present in some cases.

## 5. DISCUSSION OF THE RESULTS

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Innovation process models have been discussed primarily at the level of business practice and their implementation possibilities. In the wake of economic practice and in response to its needs, various concepts of these processes have emerged. The study did not address one important feature that should be considered, i.e., how the discussed models fit in with the concept of sustainable development. This is one of the more interesting themes found in recent literature. A review of sustainable innovations in the evolutionary process was made by Afeltra et al. (2021). The authors systematised the scientific literature on sustainable innovation to highlight key researchers and their research contributions. In addition, existing and proposed future research directions are described. The applied methodology, namely, the Systematic Literature Network Analysis, is noteworthy because it uses a dynamic approach to the traditional Systematic Literature Review. The obtained results showed that sustainable innovation refers mainly to the environmental aspect, neglecting the other two — economic and social. Thus, a direction for innovation research was indicated, which overlaps in part with the results obtained by the authors of this article, as it was also noted here that models tend towards greater sustainability. However, in contrast to the cited results, those presented here show the increasing importance of the social aspect.

Innovative approaches to the implementation of innovations are based on increasingly new concepts

(Gebauer, 2011), noting that the current shift is from technology-driven innovations to consumer (user) co-created innovations, which was also partly confirmed by the author's research. According to Gorynia (2018), the latest concepts even go beyond the national framework and require collaborative teamwork not only at the national level but also internationally. This researcher concludes that the links between innovation, productivity, competitiveness and international economic cooperation are extensive, multithreaded and complex. Researchers emphasise the increasing role of human resources in the creation of innovation (Jotabá et al., 2021), which partly overlaps with the results presented here but mainly in relation to users (future customers), as in the open innovation model (Winkler et al., 2022) and especially in the UDI model. While considering issues related to innovation processes, the authors came across the latest proposals where artificial intelligence takes part in the development (and implementation) of these processes. In response to the demand, the website "What are the latest trends and development in process innovation that you should be aware of and learn from?" (2023) was developed with AI. As scientists increasingly emphasise, it seems that the future of innovation will be increasingly dependent on AI (Kuziar et al., 2023).

## CONCLUSIONS

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The development of concepts concerning the effective elaboration and implementation of innovations has been continuous, starting from an initial phase in the 1950s and the first half of the 1960s, when innovation process models were formulated on a linear basis, through more complex ones to models with consumer involvement and a strong emphasis on the contribution of knowledge and technology, including artificial intelligence. Innovation theory is still developing, and new, equally revolutionary proposals, such as open innovation or UDI, should be expected to emerge, as innovation is constantly evolving and the regional situation (the Russian-induced war in Ukraine) and the global situation (the SARS-CoV-2 pandemic) are accelerating the pace of its introduction.

A comparative analysis of the models allowed the main conclusions to be drawn. Namely, it should be emphasised that, as innovation theory develops, the proposed models have an increasingly complex struc-

ture and are increasingly open. This particularly applies to the latest generation models developed after 2003, i.e., after the presentation of Chesbrough's open innovation concept, but modelled on it, going to the processes developed by AI. In the authors' opinion, the UDI and three horizon models seem particularly promising here, as they largely consider the perspective of the consumer (UDI) and the resources of human and technological creativity. It should be recognised that the discussed models bring value to the theory and practice of innovation. The models should constitute an indication for practitioners who can choose a model to be used in the economic practice of their organisation.

As the comparative analysis has a partly intuitive, authorial nature and appears to be the first such attempt at comparisons, it is advisable (necessary) to undertake polemics by other authors and continue research inquiries. A recommendation for further research seems obvious, but it would be equally advisable to implement the developed models to a greater extent in economic practice.

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