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Six Helix Model Of The Innovation Ecosystem Of Research And Innovation

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Abstract: The Six Helix Model of the innovation ecosystem of research and innovation was proposed. This model based on the theoretical analysis of evolution the scientific- technical conceptions, triple helix models, open innovation models, innovation process models, transfer and commercialization models, technological level of readiness model.

Keywords: models, research, opean innovations, innovation ecosystem.

1. Introduction

Innovation economics is the transformation of knowledge into innovative products, processes and services that promote economic growth, increase competitiveness and improve living standards. Research and innovation in the economically developed countries of the world are been considered as the main source of economic growth, however, the benefits, whether at the national, regional or corporate level depends on the efficiency and ability of research and innovation systems. The using of the open innovation conception strengthen the collaboration of the participants of creating and implementation innovations within the framework of innovation ecosystems.

2. Research Of Existing Solutions Of The Problem

The historical development of scientific and technical policy of developed countries has gone from the application of conceptions "scientific impetus", "problem solving", "science - source of strategic opportunities" to concept of "innovative systems of economic innovation", when knowledge and innovation are considered, as key factors in economic competitiveness and play a major role in economic growth of most countries [1].

A key feature of the innovation system is that innovation no longer perceived as a separate phenomenon that occurs only within certain organizations, and this is a joint systemic cooperation of several participants in innovation. For example, "national innovation systems" include industrial and government research laboratories, research universities, research organizations, and industrial policy agencies that provide the core of national innovation systems. [2-4].

Sectoral innovation systems provide a multidimensional, integrated and dynamic approach to the set of innovative products that carry out market and non-market interaction to create, produce and sell these innovative products [5].

Regional innovation systems determine the contribution of regional research to the national innovation system based on perceptions of regions that have different levels of innovation potential and position on innovation policy [6].

Technological innovation systems determine the delimitation of innovation systems by technology or group of technologies instead of the delimitation of the system by geography [7].

Thus, innovative systems of different levels (national, regional, sectoral, technological, local) involve the creation, dissemination, use of knowledge using external and internal components of the system and the links between these components [8].

The development of models of the innovation process from a linear process of closed innovations to model of open innovation led to the transition from the application of the approach of internal innovation to the application of the approach of open innovations [9, 10].

In the conditions of using open innovations there is a transition from the use of closed innovation system to open innovation system with the use of external knowledge, market orientation of external ideas, creating effective business models and effective combination of internal and external knowledge and resources [10, 11].

The development of Triple Helix models has come a long way substantiation of the levels of the different relations, interactions and partnership between the universities, industries and government [12-14].

The Triple Helix model of the third level are opens interaction for third parties and offers approaches to information and knowledge processing between partners from different points of view, offering new opportunities to improve knowledge creation and innovations aimed at solving social problems [15-17].

The development of transfer and commercialization of innovations models has gone way from the application of models of direct and reverse transfer of internal innovations to models of transfer of open innovations [18-20].

The improvement in the management of the process transfer and commercialization innovations related are used the technological readiness level (TRL) model which are used to monitor technological maturation innovations and transition time from one technological level of readiness to other [21].

A subsequent development of theoretical approaches was a model of open innovation process, based on the Triple Helix model, technological level of readiness model that responds to dynamic market changes [22].

The new scientific and technical policy based on the concept of "Open innovation, open science which open to world" are lead changes at the research and innovation processes that become more global with using networked international cooperation the within framework of research and innovation systems [23].

Each set of interconnected entities, whose collective actions lead to a certain result of development, is "ecosystem". Therefore, began to apply an "ecosystem" approach to the effective creation and implementation of innovations, which requires coordinated joint action and resources of interconnected participants - collectively called "innovation ecosystem", which can operate at different levels (local, regional, sectorals, nationalatys) [24].

The concept of "innovation ecosystem" has become increasingly popular in recent years due to the peculiarities of the links of this system with the concepts of "open science", "open innovation" and the triple helix model.

Definitions of the «innovation ecosystem», which were given by various authors is shown in table 1

. Table 1

Definitions of the «Innovative ecosystem»

Source	Definitions
[25]	Innovation ecosystems are clusters, physical or virtual, in which innovation activities on certain topics are concentrated. These may include entrepreneurs, universities, government agencies, innovation laboratories and accelerators, as well as influential people.
[26]	The innovation ecosystem is a large number of diverse actors and resources needed for innovation. These include entrepreneurs, investors, researchers, university professors, venture capitalists, as well as business development professionals and other technical service providers such as accountants, designers, contract manufacturers and training and professional service providers.
[27]	The innovation ecosystem is a system for the reusability of new sustainable business models and consists of people, as well as processes and systems that can support the concept from idea to scale innovation through interaction.
[28]	The innovation ecosystem is an intertwining of networks of multilevel relationships, through which relevant knowledge and creativity pass through the structure of sustainable collaborative creation of values, technologies and innovations with open thinking and encourage responsible inclusive use of resources.
[29]	Innovative ecosystem is an organizational space designed for the joint creation of values through the cooperation of actors, interaction generated by the joint activities of networks of various shapes and sizes and can be seen as an environment for collective decision-making and collective action.
[30]	The innovation ecosystem is a tool for the joint creation and implementation of innovations to market. Innovative ecosystems are organizational spaces designed to co-create values through the collaboration of a collection of actors, assets and interactions or means of communication generated by the co-operation of networks of different shapes and sizes.
[31]	Innovation ecosystem - describes the large and diverse range of participants and resources that contribute to continuous innovation in today's economy.
[32]	Innovation ecosystem - describes the large number of different actors and resources needed for innovation. These include

	"entrepreneurs, investors, researchers, university professors, venture capitalists, as well as business development professionals and other technical service providers such as accountants, designers, contract manufacturers and training and professional development service providers
[33]	The innovation ecosystem is an intertwined network of multilevel relationships through which relevant knowledge and creativity pass through the structure of sustainable co-creation of values. These complex relationships between players are aimed at ensuring the development of technology and innovation with open thinking and encouraging responsible and inclusive use of resources.
[34]	The innovation ecosystem is a multilevel structure in which institutions interact with each other to develop and share information and knowledge necessary for the development of new innovation processes.
[35]	The national innovation ecosystem uses an integrated multi-level structure. The first level the national innovation policy and the management structure of innovation at the national level. The second level of innovators and institutes that connect them (companies, research institutes that innovate and conduct research, private and public demand for innovation efforts and intermediaries that connect participants in the innovation mechanism). The third level - factors that promote innovation and ensure the smooth operation of the innovation mechanism.
[36]	National innovation ecosystem - consists of six main blocks: infrastructure, intellectual capital, integrity, incentives, interaction and institutional coordination, innovation.
[37]	National Innovation Ecosystem - based on the strategic principle of quality, not quantity and consists: IDF, domestic and foreign business R&D, defense R&D, public research universities and government agencies characterized by geographical and institutional proximity, as well as relative independence and relative independence initiative, ingenuity and experimentation that complement institutional arrangements.
[38]	The regional innovation ecosystem aims to create and grow business and innovation, as well as the business environment needed to develop a more innovative regional economy and increase the competitiveness of small and medium-sized enterprises. large enterprises (SMEs).
[39]	Corporate innovation ecosystem - combines five principles: innovation as part of the overall strategic goals of the organization; portfolio of innovative products, services (innovative projects); innovative organizational structure that provides portfolio management of innovative products, services (innovative projects); investment methods and indicators to measure success.
[40]	The ecosystem of innovative production processes includes a community of: large producers; SMEs that produce parts and components for manufacturers; startups; universities and research organizations.
[25]	Innovation ecosystems are clusters, physical or virtual, in which innovation activities on certain topics are concentrated. These may include entrepreneurs, universities, government agencies, innovation laboratories and accelerators, as well as influential people.

As the analysis of the development of the terms innovation ecosystem has shown, there are different definitions given by different scientists in different contexts (table 1).

However, there are factors that combine the existing definitions: a research economy driven by basic research and a commercial economy driven by a market. The innovation ecosystem aims to generate new knowledge, ideas and innovate, so research organizations and universities should support research with commercial potential, support startup environments and private sector collaboration.

As the terminological analysis of the definitions (table 1) of the term "innovative research ecosystem" shows, it has not established yet.

The basis of the innovation ecosystem is a network of participants. Collaboration and partnership within the innovation ecosystem better stimulates the creation of new knowledge and innovations. New sources of financial support and stimulation of innovation may become available on the connections of partners in the innovation ecosystem [41].

Typical actors of the innovation ecosystem: research organizations; incubators; venture companies; joint stock companies; governments that create policies and regulatory environments to stimulate research and innovation; development agencies looking for new and innovative ways to solve social and economic problems; professionals (human capital), which is the center of the innovation ecosystem; market intermediaries; startup companies and enterprises [42].

The innovation ecosystem approach has three important areas: a wider range of innovations, an innovation-friendly environment and various ecosystem studies. First, research has determined that in order for an ecosystem to survive and thrive, it must have various forms of internal interaction and between different other types of ecosystems. Second, an innovation-friendly ecosystem encourages collaboration, networking, critical and creative thinking, and diversity to create and bring new products and services to market. Third, in order to create a complete picture of an environment conducive to innovation,

it is necessary to use systematic incentives to generate ideas that generate innovative companies. Thus, the innovation ecosystem is focus on the direct joint creation of innovation, or the formation of an innovation environment, as a network of stable links between individuals and organizations, arising from a shared vision of the desired innovation transformations that provide economic context. Innovative ecosystems can have different scales and designs, functioning at the national, regional, local level, as well as at the level of networks, special groups, communities, etc. [43].

The development of innovation ecosystem models has led to the presentation of the innovation ecosystem as a multilevel structure in which institutions interact with each other to develop and share information and knowledge needed to develop innovation processes that no longer develop within enterprises and organizations. Broad interaction with the environment, in which various players are involved, embedded in an innovative ecosystem that uses external knowledge and resources that generate an innovative way of thinking. The modern innovation ecosystems have a high level of interaction between key players such as research organizations, universities, businesses, suppliers, competitors, users to create value chains [44-46].

An effective innovation ecosystem uses open innovation that opens an innovation process that aims to generate new ideas and innovations and uses available tools to improve the quantity and quality of new ideas and innovations in the innovation process that must be reliable to develop, manage and commercialize innovation [47].

Thus, many publications have shown that open practices stimulate research and development of innovation; however, the relationship between open science and open innovation and open to the world within innovation ecosystems remains less studied.

3. Research Results

The Six Helix Model of the innovation ecosystem of research and innovation is proposed. This model are defines and unites institutional structures of international and national partnerships (academic and university research groups - enterprises – government organizations) in six institutional environments. The model substantiates the needs to create crossing and penetration environments for simultaneous execution of the research process and commercialization process through an open innovation process and joint research and innovation projects with the involvement of interested third parties (agencies of development, joint stock companies, angel investors and venture companies) to support incubators and spin companies, fig.1.

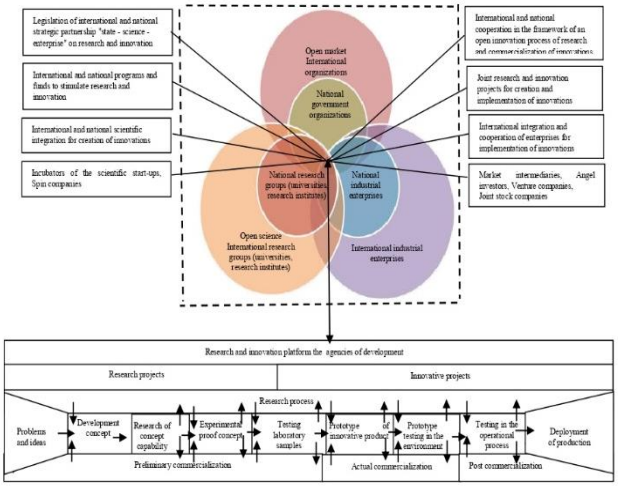

Fig.1 *Six Helix Model of the innovation ecosystem of research and innovation*

The main role of research institutes and universities to develop innovative products within the framework of research projects and creation prototype of innovative products, assessment of value and its competitive within the framework of innovation projects with simultaneous phased the commercialization of innovative products by means of the creation of scientific start-ups and spin companies jointly with enterprises. The main role of enterprises transfer of innovations of scientific start-ups and spin companies to a higher level of technological readiness for large-scale introduction them to the markets. The main role of the international and national state agencies to directed to creation and using legislation instruments and financial instruments to stimulate research and innovation within the framework programs and funds of the international scientific and industrial integration and cooperation.

The network platform of cooperation serves as a place of open collaboration and integration of resources of various participants of the innovation ecosystem. Association of innovation ecosystem participants in the physicals and virtual areas of the network platform becomes critical for open cooperation of innovation ecosystem participants. Also, between innovation developers and consumers can be interaction in a common the physicals and virtual areas of the network platform of cooperation, which allows customers to participate in the process of creating innovative products.

The development agency is the coordinator of the innovation ecosystem of research and innovation, which has a hybrid organizational structure and is at the intersection of six spirals. The main role of the development agency is to coordinate relations between scientific start-up companies, spin companies of the research institutes/universities and industrial enterprises within the framework support of state institutions and involment of the investors, market intermediaries, financial institutions and civil societies. The development agency unites and coordinates the interaction of participants in the innovation ecosystem for the implementation of research and innovation projects, the

implementation of which is stimulated through the initiation of government programs. The stage of preliminary commercialization consists of measures to markets research and launch the scientific start-ups. The stage of actual commercialization consists of measures to launch the spin companies including create a prototype product, its testing and evaluation by consumers. The post-commercialization stage consists of testing prototypes in the operational production processes of enterprises, the formation of supply chains, expansion production and distribution of innovative products.

The Six Helix Model allows apply the approach of open innovation, which opens the scientific process, innovation process and the process of commercialization in the framework of joint research projects and innovation projects involving external participants and external resources.

The Six Helix Model substantiates the need for institutional penetration and the creation of common environments to combine financial, material and intellectual resources of institutional structures for the creation and implementation of open innovation in joint research projects and innovation projects in the open innovation process.

The main advantage of the proposed Six Helix Model of innovation ecosystem of research and innovation is the ability to accelerate the development and implementation of innovations by involving at earlier stages of the research process and innovation cycle of commercialization with parallel implementation in three phases: pre-commercialization, actual commercialization and post-commercialization.

The pre-commercialization phase consists of market research activities, preparation and launch of academic startups. The stage of actual commercialization consists of measures to create a prototype product, its testing and evaluation by consumers. The post-commercialization stage consists of testing prototypes in the operational production processes of innovative enterprises, forming supply chains, expanding production and distribution of innovative products.

The application of the proposed model involves the assessment of indicators of sub-processes of the open innovation process within the organizational and economic mechanism that establishes a direct theoretical and practical relationship between the stages of the open innovation process.

Thus, the implementation of the Six Helix Model allows to develop a research environment to create new knowledge, ideas that are transformed into innovative scientific and technical developments with commercial potential and to form and develop an environment of startups, spin-offs and innovative companies to transform innovative scientific - technical developments in new products introduced to the market.

4. Conclusion

Terminological research has shown that the definition of the definition «innovation ecosystem of research and innovation» has not established yet.

Improved understanding of the relationship between open science and open innovation and their openness to the world, through proposed Six Helix Model of innovation ecosystem of research and innovation, with Six Helix interaction of the partnership between the scientific organizations (universities), industrial enterprises and state institutions including stakeholder involvement. The proposed Six Helix Model of open innovation ecosystem of research and innovation the simultaneous implementation stages of research process, innovation process and commercialization process in the three stages (pre-commercialization, commercialization and post-commercialization) are based.

The application of the developed Six Helix Model within the framework of organizational, economic and legal mechanisms allows: to increase the competitiveness of scientific organizations (universities), industrial enterprises and state institutions through optimize the process of research/innovation activities and speed-up process of the commercialization.

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