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The Development of an Interaction Mechanism between Universities and Other Innovation System Actors: Its Influence on University Innovation Activity Effectiveness

Aleksandra Kobicheva *, Tatiana Baranova and Elena Tokareva

Institute of Humanities, Peter the Great St. Petersburg Polytechnic University, Saint Petersburg 195251, Russia; baranova_ta@spbstu.ru (T.B.); tokareva_eyu@spbstu.ru (E.T.)

* Correspondence: kobicheva_am@spbstu.ru

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Abstract: The innovative economy is based on effective interaction between the scientific and educational sphere and the business environment, free flow of innovative ideas, and active commercialization of developments in order to constantly update and develop the domestic economy through new technologies. At the moment, a model of effective interaction between universities, business structures, and government in Russia has not been built. This research is aimed to develop a mechanism for multilateral interaction between universities and other participants in the innovation system, which ensures the activation of scientific and innovative activities, acceleration of the transfer process, and effective commercialization of innovative ideas. Methods. To evaluate the effectiveness of the offered interaction mechanism based on the open innovation platform we conducted a complex multi-criteria assessment of forecast indicators of a university's innovation activity effectiveness. We conducted two online surveys. Heads of scientific laboratories at the university (N = 4) and representatives of business (N = 3) acted as experts. The first survey was intended to indicate the weight of innovation activity indicators reflecting the significance of these indicators in the framework of innovation development. In the second survey, experts defined the forecast indicators of the university's innovation activity after implementation of the proposed interaction mechanism. Results. The conducted study revealed the importance of enhancing cooperation between universities and other innovation system actors for achieving higher results of innovation activity. The calculation of the effectiveness of the offered interaction mechanism showed positive influence on the university's innovation activity indicators. Thus, the mechanism can be used by multidisciplinary universities to increase their innovation activity indicators as well as the potential of all interacting entities.

Keywords: innovation system; open innovations; scientific cooperation; interaction effectiveness

1. Introduction

The transition of the Russian economy to an innovative development trend and the implementation of the import substitution strategy in highly developed knowledge-intensive industries naturally predetermine the need for an in-depth scientific and practical study of the place and significance of the university in the innovative development of Russia, as well as its interaction with the business environment. According to the analysis of the Global Innovation Index indicators [1] and indicators of university interaction with business (U-Multirank data) [2], it can be noted that in the countries with the highest index of innovative development the level of interaction between universities and business structures is high. Thus, one of the most important factors of innovative development is the strengthening of integration between the scientific and educational sphere and business.

Nowadays, universities become territorial centers of innovation activity. The activities of universities are aimed both at generating new knowledge and forming personnel for the new economy, as well as organizing the transfer of this knowledge for business purposes and attracting off-budget sources of financing. Particular importance is given to the effective use of the existing innovative potential of the university, the formation of sustainable ties and relationships between the university, external business structures, and the state, as well as the integration of the university into the national innovation system (NIS) [3].

At the moment, harmonious interaction between the participants of the national innovation system of the Russian Federation has not been established, the management system for the transfer and commercialization of university science has not been built, and innovations are created very slowly and hinder the innovative development of the country's economy [4]. The interaction of universities with external participants in the scientific community in the Russian Federation is developing unstably, since there is no developed interaction mechanism that is recognized as effective for all participants in the scientific environment [3,5]. At the moment, scientific cooperation is more advanced within each individual organization, which hinders the development of innovations. This situation is caused by the lack of theoretical knowledge about effective external scientific cooperation and the promotion of innovative ideas. The lack of a relevant mechanism for interaction between scientific communities also slows down the process of commercialization of innovations. The interaction mechanism should be based on appropriate tools that could activate university-business interaction and facilitate the exchange of knowledge and results of innovation activity (RIA), therefore providing the base for innovation economy formation.

Which form of interaction between innovation system actors is the most appropriate in Russia today? What should be the basis of an effective interaction mechanism? How should the effectiveness of the interaction mechanism be measured? These are still unresolved issues in the Russian market that make the study relevant and predetermine the goal.

This paper is structured in the following way. Section 2 describes the theoretical background on the open innovation perspectives as the key concept of improving innovation activity efficiency due to permanent interaction and cooperation of innovation system authors. Section 3 defines the methodological basis of the research. Referring to the conclusions of the theoretical background, the effectiveness of the interaction mechanism is evaluated by the innovation activity indicators that are highlighted. Then, a detailed description of the conducted research stages is presented, and the main methodology tool is described. The next section contains the main research results. Finally, the obtained results are discussed in the context of other research studies (Section 5). Appendix A presents "Survey on forecast indicators of university's innovation activity". Appendix B reflects "Survey on weight values of innovation activity indicators".

2. Theoretical Background

2.1. Theoretical Background

Open science as a phenomenon is based on two fundamental mechanisms of science organization: openness and sharing [4–7]. New methods of open science used by research groups at universities, such as open data, open access publications, open protocols, open physical laboratories, crowdsourcing methods, or transdisciplinary research platforms, are based on Merton's principles of science [8], which include communalism, universalism, disinterestedness, originality, and skepticism (CUDOS norms). However, scientific practices continue to evolve. Today, open science focuses on the pursuit of "transparent and accessible knowledge that is transmitted and developed through collaboration networks" [9,10]. New methods of open science and new ways of organizing scientific work using digital platforms, tools, and services for researchers make science more accessible for citizens and the sharing of scientific results and the process of creating knowledge more effective and goal-oriented [11].

Understanding the impact of these new open scientific practices on the openness of science is the main goal of ensuring the effectiveness of research systems [4,6].

The terms "open innovation" and "closed innovation" were introduced by the American economist Henry Chesbrough [12]. He found that with an increase in the rate of exchange of information flows, the efficiency of using closed business models decreased. Open innovation focuses on the use of targeted inflows and outflows of knowledge to accelerate internal and external innovation [12,13]. The phenomenon of open innovation has also influenced how universities and research groups conduct research and contribute to innovation processes [14]. The core concept of open innovation is based on collaboration with stakeholders such as government, research organizations, customers and consumers, suppliers, and business entities seeking to combine human, financial, and material resources and information and knowledge in order to generate innovation with shared values [15]. Therefore, it includes different applications like joint R&D, technology transfer, licensing, open source software, and mass sources (crowdsource) that provide an outbound and inbound flow of information [16]. Innovation is a multi-step process [17], which includes various practices at different stages [18]. Over the past 10 years, research and policies in the field of open innovation have been aimed at developing and promoting more input than outgoing methods and processes for creating valuable knowledge [19,20]. Digital and communication technologies have created new unexplored opportunities and challenges for innovation management in universities (i.e., reliable data exchange, quality control and reproducibility of research methods and results, management of joint research platforms, funding instruments, relations between universities and industry, strategic alliances, by-products, startups, and consortia). In this regard, figuring out how research groups use the new results of open science to generate the results of open innovation is a priority in developing effective policy and management mechanisms for universities.

The acceleration of the frontier of scientific knowledge has coincided with a renewed interest in open science on the part of politicians. Open science norms promote the rapid dissemination of new knowledge and invite broader partners to participate in the discovery of new knowledge. This deepens knowledge, improves its quality, and promotes its dissemination (which then leads to a new cycle of discovery and dissemination) [16,18]. However valuable this broad participation may be, it does not guarantee the subsequent effective commercialization of scientific knowledge. Indeed, the norms of open science can in some way create problems that hinder the commercialization of knowledge.

Open innovation is a concept that can help connect the fruits of open science with the faster transformation and development of its discoveries. Like open science, open innovation involves broad and effective participation and participation in the innovation process [7].

The traditional institutions of open science [7] and the new institutions of open innovation [21,22] must be adapted, updated, and combined to effectively realize their scientific and innovative potential in the digital world. Universities are a solid foundation of open scientific and innovative practices [23–25] that contribute to innovation processes at the global, regional, national, and local levels.

Moreover, the open innovation ecosystem stimulates interaction and cooperation between universities, business representatives and government, while the high level of interaction leads to accomplishments of innovation activity results [3].

The active role of the consumer in the innovation process is emphasized in the modern "four-link helix" model proposed by E. Carayannis and D. Campbell [26] based on the "triple helix" model developed by H. Etzkowitz and L. Leydesdorff [27] at the end of the last century. According to the "triple helix" concept, the effectiveness of technological interaction is ensured through close cooperation between government, business, and universities, where all components of the "spiral" perform their functions and complement each other. At the initial stage—the generation of knowledge—there is an interaction between science (universities) and authorities (governing bodies). At the next stage—in the transfer of technologies—science cooperates with business (business circles). Market launch is ensured by joint actions of business and government. The four-link model contains the fourth element of the

"helix"-civil society as an active consumer and participant in the innovation process, and this is a key factor in achieving success.

In the countries of the European Union, for the active implementation of the theory of open innovation, so-called living laboratories are widely used, whose activities are aimed at supporting the activity of all participants in the innovation process—from manufacturers to end consumers, with a special emphasis on the participation of small and medium-sized enterprises. On the European Network of Living Laboratories website (ENoLL), they are defined as consumer-oriented open ecosystems based on collaborative creativity that integrates research and innovation processes in real life [28].

Finnish researchers of modern innovation research R. Arnkil and co-authors identify four types of models of the "four-link helix", two of which are defined by them as living laboratories [29].

- "Triple Helix + Consumers" is the traditional triple helix model, supplemented by a system for collecting and processing information from consumers. It is used in the development of commercial high-tech innovations based on the latest scientific developments. The owner of the innovation process is a firm, group of firms, university, or group of universities. Consumers are used only as a source of information.
- "The Firm-Oriented Living Lab" also focuses on commercial high-tech innovation. It can be based both on modern scientific developments and on the adapted use of earlier scientific results and/or knowledge of citizens from the outside. In this case, the owner of the innovation process is a firm or a network group of firms. Consumers in this model act not only as a source of information, but also participate in the process of creating new goods and services together with specially attracted experts.
- "Public Sector-Oriented Living Lab" aims to develop community organizations and services. In this case, the owner of the innovation process is a public organization or a group of such organizations. In order for the result of the activity to meet the requirements of customers, it is necessary to regularly receive information from them or have feedback. For this, both traditional methods are used, for example, interviews and dialogues in virtual and real forums, and a specially created environment for citizens-living laboratories. Consumers participate in the development of public services with experts.
- "The Citizen-Centered Quadruple Helix" targets the needs of specific populations. People are the driving force behind what types of new products or services are needed and are involved in their development. The owner of the innovation process can be a citizen or a group of citizens—an "initiative group". The role of firms, authorities, and universities is to support proactively [29].

From a philosophy of open innovation to a culture of open innovation, there is a need to overcome the inverted U-shaped curve of the effects of open innovation, which can also be called the paradox of open innovation [30,31]. Currently, during the fourth industrial revolution, the dynamics of open innovation is rapidly increasing with the explosion of the paradox of open innovation, which also means the complexity of open innovation [32–35]. In this situation, there is a growing need for an understanding of the culture that can control the dynamics of open innovation.

Modern society is used to a culture of cooperation and exchange that is different from the culture of previous generations. Consumers are now more interested in services and experiences than in property. In professional arenas, large communities, often online, have emerged in which people collaborate, often with minimal, and sometimes even no, direct economic value exchange and without traditional hierarchical control [36]. Culture is perceived as a set of living relationships aimed at achieving a common goal—not what you are, but what you do. While definitions of culture vary, it is clear that culture is inherent in the organization, and its top-down values and general assumptions are evident in the behavioral norms and shared experiences of its members. A firm's constructive culture directly enhances cooperation within organizational units within firms and coordination between organizational units of firms, which can indirectly improve a firm's performance [37]. An innovation

culture, that is, a static culture of open innovation, has four dimensions: market orientation, technology orientation, entrepreneurship orientation, and learning orientation [38,39] A culture of open innovation is built on values such as curiosity, creativity, flexibility, and diversity, because an open dimension requires values such as openness, trust, responsibility, authenticity, and sustainability [40,41].

Since open innovation drives the dynamics of innovation and the business models of existing firms, an open innovation culture must be dynamically defined. Open innovation dynamics has two layers: open innovation microdynamics, that is, open innovation–complex adaption–evolutionary change (OCE) dynamics; and open innovation macro-dynamics, that is, market open innovation–closed open innovation–social open innovation (MCS) dynamics [33,35]. First, entrepreneurship will drive open innovation in the microdynamics of open innovation, because open innovation means a new combination of technology and market across firm boundaries. Entrepreneurs will be interested in moving from a new mix of society and technology to a new mix of technologies and markets across firm boundaries in the macrodynamics of open innovation through new products or services, new markets, new processes, new organizations, or new materials.

Second, the internal entrepreneurship of employees of existing firms will stimulate new innovations in these firms. Thus, internal entrepreneurship will include complex adaptation in the microdynamics of open innovation.

Intrapreneurs will increase closed-open innovation in the macrodynamics of open innovation, that is, new business projects, increased innovation, self-renewal, or proactivity of existing large enterprises, which are mainly based on closed innovation, but pursue strategic goals [42].

Third, the organizational entrepreneurship of the firm itself will facilitate evolutionary change. Organizational entrepreneurship, including corporate entrepreneurship, will drive social, open innovation.

Theories of innovation implementation offer a promising approach to the study of organizational factors that affect effective implementation [43]. In higher education and research institutes, research incentive structures, the search for partners, and the lack of a culture of "openness to business" often impede external collaboration. Thus, while it is in the interest of research organizations and firms to collaborate, they do so less than is necessary. Government intervention helps to overcome such obstacles and reduce costs by subsidizing cooperation. Although the subsidy often only covers the additional costs of the collaboration (and not the actual cost of R&D), this limited financial support can be meaningful for small firms or even for R&D of large companies.

The expected result is triple and complex:

1. The actual outcome of a R&D cooperation project is a "first order effect".
2. A second important effect is a shift in the emphasis of firms and scientists towards more strategic (firms) and more problem-oriented (science) research and development activities.
3. Most importantly, such interventions develop cooperation skills and facilitate learning how to participate in and maintain collective structures (after the intervention) [44].

Such measures usually follow a step-by-step logic: supporting the search for partners and preparing projects, new networks, or joint ventures, project implementation leading to expected results, and subsequent academic, business, and social results. Evaluation of the effectiveness of innovative activities of educational institutions and research centers is carried out using the following indicators:

- Grants & financial instruments;
- Increased R&D investment leveraged by funded projects;
- Newly established or extended networks and centers;
- Scientists and engineers working on joint projects;
- Increased patents/co-publications in a specific technology field;
- Enhanced capacity to manage collaboration projects in both science and industry;
- Revenue from contract research or technological services;

- Growth in sales and/or exports of innovative products/services arising from collaboration projects [44].

2.2. Developing the Interaction Mechanism

It seems to us appropriate to build the interaction of participants in the innovation process on a network basis, as the most promising according to many scientists [20,45,46].

The offered interaction mechanism, which is based on open innovation platforms, is presented in Figure 1. University departments still interact within their system but also develop external ties through interaction with the "Living Labs". There is also a communication channel with the "Network Business Incubator". The "Business" sector and the "Government", as active participants in the innovation process, are also present at the "Network Business Incubator". Thus, on the basis of the "Network Business Incubator", there is an interaction between all participants in the innovation process: "University", "Business", and "Government". The "Living Lab" and "Network Business Incubator" are located on the online platform of open innovation, which creates a common space for joint development of innovative projects open to participation of all stakeholders. In this way there is a regular exchange of knowledge, ideas, and developments, as well as a request for potential future projects and the formation of research groups. The proposed mechanism deepens knowledge, improves its quality, and promotes its dissemination (which then leads to a new cycle of discovery and dissemination) [18]. According to the "triple helix" concept, the effectiveness of such technological interaction is ensured by close interaction between the state, business, and universities, where all the components of the "spiral" perform their functions and complement each other [27]. The implementation of this mechanism using the "Living Lab" and "Network Business Incubator" allows us to realize the model of the "four-link helix".

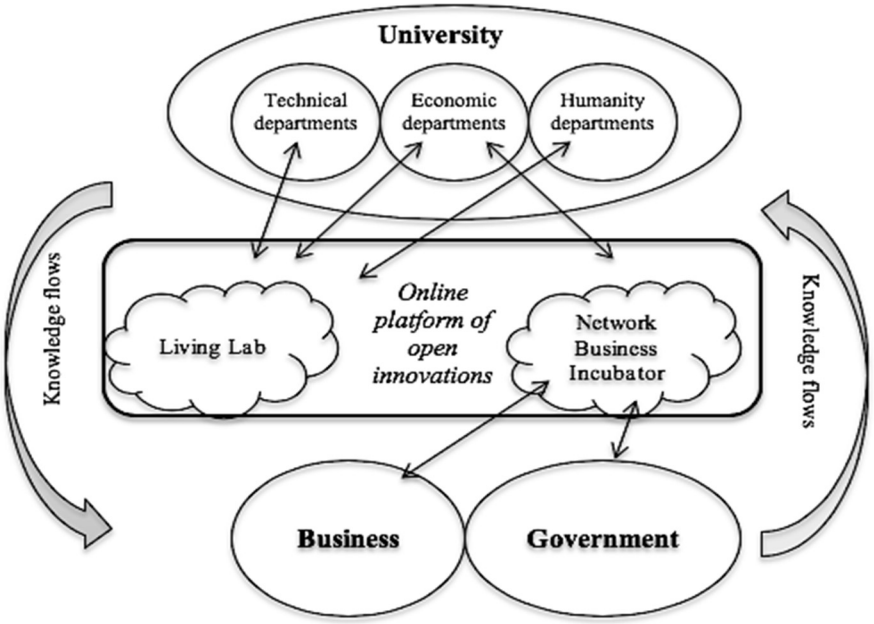

Figure 1. The mechanism of interaction between a university and other innovation actors.

It is possible to involve structural divisions (university departments) in network interaction by creating a "Living Lab", which is an open innovation ecosystem focused on active and permanent cooperation during the implementation of innovative activities due to its openness, exchange of experience, and information resources. Such laboratories are actively distributed in the countries of the European Union, transforming at the same time into various forms. In November 2006, representatives of Finland created the central organization of the living lab system in Europe-ENoLL. Despite the fact that in Russia "living laboratories" are not yet widespread, there is already a positive example of the

implementation of innovative activities in this format—"Living Laboratory in Tomsk: a smart city with a comfortable environment" [46]. Within the framework of this first project session, work was carried out on the development of project proposals by students, university scientists, specialists in this field, and experts, including international ones, from the international bureau.

A living laboratory platform is a tool for conducting and implementing innovative projects by combining the intellectual potential of scientists, students, experts, and specialists in certain fields on one online platform.

Within the framework of the living laboratory, economic departments (educational and research units) can act as a driver for promoting university innovation by performing a number of professional functions: market analysis, foresight forecasting of demand for innovations, the search for new customers, advertising campaigns, etc. All technical information will be available online to project teams of technical departments at any time. At the platform of the living laboratory there will also be an opportunity to leave applications for studies of interest and request the necessary consulting services of economic departments.

Thus, this platform may turn out to be one of the effective mechanisms of universities' interaction with other participants in the innovation process, contributing to the maximum dissemination of information about existing projects within universities, about promising areas of research for high-tech companies, timely and high-quality implementation of marketing events, and as a result a higher level of commercialization of university innovation.

The creation of a network business incubator can become an effective mechanism for network interaction with external actors of the innovation process.

Through a network business incubator, it is possible to increase the commercialization of developed innovative products and technologies of the university as an independent developer, and in cooperation with business structures through the implementation of network interaction [46].

Such business incubators form an effective organizational structure for the interaction of universities (implementing projects based on the intellectual resources of their employees, as well as the results of basic and applied research) with high-tech business structures (ready to get started on projects with a high development potential) thanks to an innovative form of network cooperation.

Virtual business incubators, whose users can resort to consulting and information services without burdening themselves with the cost of renting an office, have recently gained special popularity [47]. In addition, the advantage of a network business incubator over the traditional one is the ability to increase the number of clients by a factor of ten, due to the absence of any restrictions other than the "bandwidth of consultants" and experts providing support to innovative business structures. Considering that the interaction of consultants, experts, and clients of the network business incubator takes place on the basis of telecommunications, the geographical location of the participants does not matter, and if necessary, the circle of interested parties can be expanded [48].

Forming the conditions for interaction, the business incubator is an ecosystem for the implementation of innovative projects, which allows using the potential of all entities of the virtual platform on the basis of integration processes and the integrated use of information technologies [49,50]. Thus, by combining conditions and resources, a controlled environment is created that allows business projects at any stage to effectively develop. Due to the virtual nature of the network business incubator, the traditional incubation framework, i.e., creative groups that are not registered as a legal entity, an organization can apply for services (services for the development of statutory documents and registration are also provided by consultants). After business startups structures grow into large developed projects; consulting support for a network business incubator does not end if the company needs it.

Due to the forms and mechanisms of networking between universities and business structures based on information technology, the integration of universities, business structures, including innovative, creative associations, and investors, is being implemented, allowing the effectiveness

of joint scientific, educational, and innovative activities to increase [51]. A developed software environment is a necessary element for the implementation and use of such forms and mechanisms.

Thanks to open innovations, a wider basis for innovative ideas and technologies is provided, they can be used as a strategic tool to study the potential and growth opportunities, and on their basis higher flexibility, self-organization, and sensitivity to market changes are achieved.

Open innovations are formed within the framework of innovation networks on the principles of a three-spiral model of innovative development, combining the efforts and interests of business structures, the state, and universities, using the appropriate institutional conditions and innovative infrastructure, and organizing open innovation interaction to create innovative goods that meet the requirements of the market and are in demand by society.

The "Living Laboratory" is created for the internal cooperation of a university's educational and research organizational structures, so that they can share ideas, projects, and research results. The transparent interaction allows a synergy effect to be achieved on innovation activity. The network business incubator is formed for the close and permanent connection of the university with business structures and governmental bodies. It facilitates the communication processes and rapid funding search.

The hypothesis of our study is that the online platform of open innovation positively impacts the interaction between innovation system actors—university, business, and government—and increases the effectiveness of innovation activity of a university.

3. Materials and Methods

3.1. Data Collection and Sample

The collection of data on innovation activity indicators was carried out using various open sources of information from the official website of the university—http://spbstu.ru—and reports on innovation activity of the IPNT (Institute of Physics, Nanotechnology, and Telecommunications), Peter the Great St. Petersburg Polytechnic University.

A group of four experts from different fields of activity at the Peter the Great Polytechnic University (educational, research) and three experts from the business sector were selected and surveyed twice. The first online survey was intended to indicate the weight of innovation activity indicators, reflecting the significance of these indicators in the framework of innovation development (Appendix A). In the second online survey experts defined the forecast indicators of the university's innovation activity after implementation of the proposed interaction mechanism (Appendix B). The surveys were conducted in March 2020.

3.2. Variables

Since the developed forms and mechanisms were aimed at solving the problem of the low level of commercialization of innovations in the university, in order to evaluate the effectiveness of the implemented measures, it is necessary to analyze the research activities, reflecting the effectiveness of the ongoing research and development. We used indicators that characterize the structure of the university's income from research, publication, and patent activity according to ITMO (Russian University of precision mechanics and optics) monitoring of universities' innovation activity in Russia [51]. Thus, we distinguished four groups of indicators: (1) publication activity (the number of publications per scholar, citation of scientific works in scientific metric databases (Web of Science/Scopus, RSCI), (2) interaction with external participants (number of laboratories created by third-party organizations based at the university (participation in clusters) and the share of R&D financing under contracts with business entities in the total volume of R&D), (3) grant activity (the number of applications for tenders and the amount of R&D financing by grants), (4) intellectual property (the number of created RIA with legal protection and the number of patents in collaboration with companies). The system of indicators

for calculating the effectiveness of the implemented forms and mechanisms of interaction is presented in Table 1.

Table 1. The system of indicators for calculating the interaction effectiveness of innovation process participants.

Kind of Activity (i)	Number of Indicator (j)	Name of Indicator	Symbol. (Xij)
Publication activity	1	The number of publications per scholar (Russian base)	X_{11}
	2	The number of publications per scholar (WoS)	X_{12}
	3	The number of publications per scholar (Scopus)	X_{13}
	4	The number of publication citations (Russian base) per scholar	X_{14}
	5	The number of publication citations (WoS) per scholar	X_{15}
	6	The number of publication citations (Scopus) per scholar	X_{16}
Integral Indicator of Publication Activity			R_1
Interaction with external participants	1	The number of laboratories created by third-party organizations based at the university (participation in clusters)	X_{21}
	2	The share of R&D financing under contracts with business entities in the total volume of R&D	X_{22}
Integral Indicator of Interaction with External Participants			R_2
Grant activity	1	The number of applications for federal grants	X_{31}
	2	The amount of financing of R&D by grants per scholar (thousand rubles)	X_{32}
Integral Indicator of Grant Activity			R_3
Intellectual property	1	The number of RIA created with legal protection	X_{41}
	2	The number of patents in collaboration with companies	X_{42}
Integral Intellectual Property Indicator			R_4

3.3. Methodology of University's Innovation Activity Evaluation

At the first stage, it is necessary to bring the system of indicators into a comparable form in order to ensure the possibility of calculating the integral indicator of evaluating the results of the innovative activities of the university. For this, it is proposed to carry out the procedure of standardizing indicators.

The procedure for normalizing each X_{ij} indicator will be carried out by calculating its actual value relative to the standard value adopted at the university. Reference values can be contained in the development strategy of the university (roadmap) and change as a result of changes in the target values of indicators. In the absence of target indicators in strategic plans, the maximum value of the indicator for a number of years can be chosen as the basis. Rationing of an indicator is carried out according to Equation (1).

$$r_{ij} = \frac{X_{ij}}{a} \times 100\%, \quad (1)$$

r_{ij}—the normalized value of the indicator X_{ij}, is in the range from zero to one;

X_{ij}—the value of the j-th indicator for the i-th type of activity;

a—reference value of an indicator X_{ij}.

In the second stage, it is necessary to determine the weight coefficient, which reflects the significance of various indicators by types of innovation in the general system of indicators. For this, it is proposed the method of expert assessments is used (the first survey).

The need to calculate the integral relative indicator for each type of innovative activity (R_i) is due to the fact that in order to assess the level of interaction between the structural units of the university and innovative actors, there is a need to determine the weighting coefficients of indicators, reflecting the significance of each of them by type of innovative activity. It is also proposed to do this on the basis of using the method of expert assessments, which allows the weight value of each i-th type of innovative activity to be determined in its total volume (K_i). The value K_i is formed on the basis of the summation of the values k_{ij} obtained during the same expert survey.

To participate in this survey, experts are selected from among the representatives of management involved in the management of innovative processes of higher education, representatives of the scientific community, and the teaching staff.

For each indicator X_{ij}, the expert sets the weight value of the j-th indicator for the i-th activity.

$$\sum_{m=1}^{M} k_{ij} = 1, \tag{2}$$

k_{ij}—weight coefficient of the significance of the j-th indicator for the i-th type of innovation;

M—number of indicators in the system used.

Based on the previously obtained values of r_{ij} and expert estimates k_{ij}, the integral relative indicator for each type of innovative activity (R_{iY}) is calculated in accordance with Equation (3).

$$R_{iY} = \sum_{l=1}^{L} r_{ij} \times k_{ij}, \tag{3}$$

R_{iY}—integral relative indicator for each type of innovation;

l = 1, 2, . . . , L—the number of indicators for the i-th type of innovation.

It is proposed that the problem of the presence of different values of expert assessments of significance for X_{ij} indicators is solved by calculating the weighted average value when the conditions for the consistency of expert opinions identified as a result of calculating Kendall's concordance coefficient are satisfied. When calculating the level of integration of the university in the NIS, this indicator is used due to the presence of attributes of factors and the need to use an expert method to evaluate them. The value of this indicator above 0.4 indicates a fairly high consistency of opinions and the possibility of using the survey results to calculate the weighted average. For a higher reliability of results, a minimum of four experts are needed to test for consistency of expert opinions.

The calculation of Kendall's concordance coefficient is carried out by building the elements of the population from the most to the least important indicator. After ranking n elements (indicators), we get m sequence of ranks (number of experts).

$$\mathrm{CON} = \frac{12S}{e^2(n^3 - n)} \tag{4}$$

CON—Kendall's concordance coefficient, CON ∈ [0;1];

e—number of experts in the group;

n—number of indicators;

S—the sum of squares of rank differences (deviations from the mean).

Based on the system of indicators, it will be possible to construct a matrix of multicriteria assessment of the level of effectiveness of interaction (Table 2).

Table 2. Matrix of multicriteria assessment of the level of interaction effectiveness.

Name of Indicator	Years				Coef. Significance
	2019	2020	...	№Y	
Block 1. Publication Activity					
1. The number of publications per scholar (Russian citation base)	r_{111}	r_{211}	...	r_{Y11}	k_{11}
2. The number of publications per scholar (WoS)	r_{112}	r_{212}	...	r_{Y12}	k_{12}
3.The number of publications per scholar (Scopus)	r_{113}	r_{213}	...	r_{Y13}	k_{13}
4. The number of publication citations (Russian base) per scholar	r_{114}	r_{214}	...	r_{Y14}	k_{14}
5. The number of publication citations (WoS) per scholar	r_{115}	r_{215}	...	r_{Y15}	k_{15}
6. The number of publication citations (Scopus) per scholar	r_{116}	r_{216}	...	r_{Y16}	k_{16}
Integral relative measure of publication activity	R_{11}	R_{12}	...	R_{1Y}	K_1
Block 2. Interaction with External Participants					
1. The number of laboratories created by third-party organizations based at the university (participation in clusters)	R_{121}	r_{221}	...	r_{Y21}	k_{21}
2. The share of R&D financing under contracts with business entities in the total volume of R&D	R_{122}	r_{222}	...	r_{Y22}	k_{22}
Integral relative indicator for interaction with external actors	R_{21}	R_{22}	...	$R2_Y$	K_2
Block 3. Grant Activity					
Amount of funds attracted for R&D/total number of scholars * 100	R_{131}	R_{231}	...	r_{Y31}	k_{31}
The number of RIAs created with legal protection/total number of scholars * 100	R_{132}	R_{232}	...	r_{Y32}	k_{32}
Integral relative indicator for grant activities	R_{31}	R_{32}	...	R_{3Y}	K_3
Block 4. Intellectual Property					
The number of RIA created with legal protection	r_{141}	r_{24}	...	r_{Y41}	k_{41}
The number of patents in collaboration with companies	r_{142}	r_{242}	...	r_{Y42}	K_{42}
Intellectual property integral relative ratio	R_{31}	R_{32}	...	R_{3Y}	K_4

In Table 2, the following notation is used: k_{ijU}—the relative value of the j-th indicator for the i-th type of innovation in the Y-year, K_{iU}—integral relative indicator for the i-th type of innovation in the Y-year, P_i—coefficient of the significance of the integral relative indicator for the i-th type of innovation, F_Y—assessment of the effectiveness of the university's interaction with innovative actors in the Y-year.

A comprehensive measure of the interaction efficiency F_Y is the sum of the relative dimensionless estimates of the indicators R_{iY}, which are determined using Equation (3) (Equation (5)).

$$F_Y = \sum_{l=1}^{L} R_{iY}, \quad (5)$$

I—index group number, i = 1,2,3 . . . , n;

Y—year of assessment.

Using this indicator, we can determine the indicator of the interaction of all structural departments of the university with the actors of the innovation process as well as the effectiveness of innovation activity at the university.

As the mechanism was introduced during the study, we propose to calculate the effectiveness of the implemented interaction mechanism on the basis of forecast estimates of indicators.

Below is a predictive assessment of the performance of SPbPU research activities taking into account the mechanisms for developing interaction proposed (Table 3). The predictive assessment was carried out using the method of extrapolation of retrospective data for five years (scenario A) and the expert method (scenario B). The forecast in scenario B shows indicators taking into account the implementation of the proposed forms and mechanisms of interaction based on the constant cooperation of employees both within the university and with external participants (the second survey results).

Table 3. Scorecard for evaluating the effectiveness of introducing a new interaction mechanism.

№	Indicators	Scenario	2018 Actual	2019 Actual	2020 Forecast	2021 Forecast
	Publication Activity					
1.	The number of publications per scholar (Russian base)	A	10.0	10.5	10.71	10.98
		B			11.5	12.5
2.	The number of publications per scholar (WoS)	A	1.9	2.5	2.82	3.22
		B			3.1	3.7
3.	The number of publications per scholar (Scopus)	A	3.1	4	4.67	5.4
		B			5.2	6.5
4.	The number of publication citations (Russian base) per scholar	A	12.4	14.2	15.31	16.7
		B			15.5	16.8
5.	The number of publication citations (WoS) per scholar	A	4.5	6.7	6.78	7.6
		B			7	7.9
6.	The number of publication citations (Scopus) per scholar	A	6.2	9.5	9.94	11.5
		B			10.8	12
	Interaction with External Participants					
7.	The number of laboratories created by third-party organizations based at the university (participation in clusters)	A	0	0	0.7	0.8
		B			1	2
8.	The share of R&D financing under contracts with business entities in the total volume of R&D	A	28.3	28.8	29.276	29.98
		B			32	35
	Grant Activity					
9.	The number of applications for federal grants	A	48	70	69.9	78
		B			70	80
10.	The amount of R&D financing by grants in one research and development work (thousand rubles)	A	25.7	28.8	31.137	33.86
		B			30.1	34.2
	Intellectual Property					
11.	The number of RIA created with legal protection	A	10	14	14.4	16.2
		B			16	20
12.	The number of patents in collaboration with companies	A	0	0	0	0
		B			1	2

Notes: A—indicators excluding the implementation of the mechanism; B—after the introduction of the mechanism of continuous cooperation between structural units of the university among themselves and with participants in innovative activities.

To calculate the effectiveness of the interaction between structural units with each other and with external participants in innovation, we propose using forecast indicators for 2021 according to scenarios A and B.

The effectiveness of the implemented forms and mechanisms of interaction will be calculated according to Equation (6).

$$W = F_B - F_A \quad (6)$$

F_B—effectiveness of interaction without taking into account the implementation of measures;

F_A—the effectiveness of the interaction after the introduction of the mechanism of continuous cooperation.

4. Results

The results of calculating the concordance showed that the consistency of experts' opinions is quite high; the coefficient was 0.6, which indicates the presence of similar opinions regarding the influence of one factor or another on the level of effectiveness of the university's interaction with participants in the innovation process, as well as on the forcing of a single image of the future university.

Based on the results of the first survey, the calculation of the consistency of experts' opinions in the areas of publication activity, interaction with external participants, competitive activity, and intellectual property made it possible to distribute weight coefficients according to indicators included in a comprehensive indicator of the level of effectiveness of the university's innovation activity and internal/external innovative interaction (Table 4).

Table 4. The results of an expert survey and the calculation of weighted indicators for assessing the effectiveness of interaction.

Indicator/Expert	Expert 1.1.	Expert 1.2.	Expert 2.1.	Expert 2.2.	Expert 3.1.	Expert 3.2.	Expert 3.3.	Coefficient of Significance, k_i
K_1	**Publication Activity**							**0.24**
X_{11}	0.024	0.027	0.03	0.022	0.025	0.028	0.025	0.026
X_{12}	0.05	0.049	0.047	0.055	0.045	0.047	0.052	0.049
X_{13}	0.061	0.056	0.055	0.064	0.058	0.055	0.059	0.058
X_{14}	0.018	0.025	0.027	0.02	0.024	0.026	0.023	0.023
X_{15}	0.041	0.04	0.038	0.047	0.04	0.035	0.039	0.04
X_{16}	0.047	0.044	0.042	0.047	0.041	0.044	0.046	0.044
K_2	**Interaction with External Participants**							**0.3**
X_{21}	0.09	0.12	0.11	0.13	0.1	0.12	0.1	0.11
X_{22}	0.21	0.19	0.2	0.2	0.17	0.21	0.19	0.19
K_3	**Grant Activity**							**0.15**
X_{31}	0.062	0.05	0.064	0.068	0.063	0.057	0.059	0.06
X_{32}	0.079	0.093	0.09	0.088	0.095	0.093	0.094	0.09
K_4	**Intellectual Property**							**0.31**
X_{41}	0.16	0.19	0.15	0.13	0.16	0.19	0.16	0.16
X_{42}	0.14	0.13	0.17	0.16	0.15	0.18	0.14	0.15

We summarize the data obtained from the system of indicators for assessing the effectiveness of interaction in Table 5. Scenario A was calculated based on the results obtained using the method of extrapolation of retrospective data for five years. Scenario B is the forecast results obtained using a survey of experts.

Table 5. Interaction performance indicators.

Interaction Level Indicators	2021 (Scenario A)	2021 (Scenario B)
	Publication Activity	
X_{11}	10.98	12.5
X_{12}	3.22	3.7
X_{13}	5.4	6.5
X_{14}	16.7	16.8
X_{15}	7.6	7.9
X_{16}	11.5	12
	Interaction with External Participants	
X_{21}	0.8	2
X_{22}	29.98	35
	Grant Activity	
X_{31}	78	80
X_{32}	33.86	34.2
	Intellectual Property	
X_{41}	16.2	20
X_{42}	0	2

Based on the sum of the products of normalized values and weighted values of the indicators, we calculate the integral indicator and indicators for innovation groups. We summarize the data in Table 6.

Table 6. Indicators for assessing the level of interaction effectiveness after normalization.

Interaction Level Indicators, r_i	2021 (Scenario A)	2021 (Scenario B)
	Publication Activity	
r_{11}	95.47	108.69
r_{12}	92.00	105.71
r_{13}	94.73	114.03
r_{14}	101.21	101.81
r_{15}	100.00	103.95
r_{16}	100.00	104.35
R_1	23.21	25.71
	Interaction with External Participants	
r_{21}	80.00	200.00
r_{22}	93.17	117.6
R_2	26.5	44.34
	Grant Activity	
r_{31}	111.43	114.28
r_{32}	112.86	114.00
R_3	16.84	17.12
	Intellectual Property	
r_{41}	98.18	121.21
r_{42}	0.00	200.00
R_4	15.7	49.39
F_Y	**82.25**	**136.56**

Based on the calculation results (Equation (6)), the values of the interaction level of university structures among themselves and with participants in the innovative activity, as well as the effectiveness of the implemented forms and mechanisms of interaction, are obtained and presented in Table 7.

Table 7. Indices of the interaction effectiveness level and the effectiveness of the implemented forms and mechanisms of interaction.

	R_1	R_2	R_3	R_4	Index Value F_Y	Index Value W
Scenario A 2021	23.21	26.5	16.84	15.7	82.25	**56.31**
Scenario B 2021	25.71	44.34	17.12	49.39	136.56	

According to the obtained values, the implementation of the developed interaction mechanism will have a positive effect on the effectiveness of interaction both within the university and with external participants in the innovation process, as well as on the effectiveness of the university's innovation activity. The indicator of the innovation activity effectiveness of scenario A forecast values is lower than the indicator of the innovation activity of the scenario B forecast values by 39.77%, which indicates a significant impact of the implemented mechanism on the effectiveness of the university's innovation activity and the level of interaction. Thus, our hypothesis was confirmed.

5. Discussion: Open Innovation by Interaction between University and Other Innovation System

From the Enlightenment, when the norms and practices of open science were formulated [7], to this day, openness in science has continued to evolve in accordance with the economic, political, sociocultural, and technological constructs of each period. The work of many scientists [4–7] has contributed to the correct perception of a new scientific space, including the ways of interaction of scientific agents to create effective communication aimed at achieving research objectives. It is important to note that the principles of open science and innovation [8,12,13] allow modern universities

to increase the share of commercialized projects, as well as promote the scientific community outside the walls of universities, reaching new levels. Based on the obtained results, our case at the Peter the Great Polytechnic University showed a positive correlation between the level of university interaction with other innovation system actors and the general level of the university's innovation activity indicators.

We developed and proposed a mechanism for the university's interaction with other actors of the innovation system based on the online platform for open innovation, which allows the effectiveness of joint scientific and innovative activities to be increased. Although policy, debate, and action at the national, regional, and global levels regarding openness in science seems to still revolve around the "sharing of scientific results" through open data and open access, there has already been a significant shift in the mindset of researchers towards greater openness in science throughout the research cycle [52] by university research groups. In our study, we proposed a mechanism for ensuring the openness of science, not only in the research process. Within the framework of the proposed mechanism, the possibility of creating project groups, analyzing topical research topics has been implemented and functionality has also been developed for business partners, which allows companies to navigate among the variety of innovations and invest in projects that they demanded.

The creation of such a mechanism was based on the concepts of open science and open innovation. Having studied these concepts and their contribution to the development of science [9,13], it was possible to implement "Living Labs" in the university environment. The openness of science contributed to the expansion of contacts among researchers, simplified the search for potential collaborators with similar scientific interests, opened access to the study of previous research, and expanded the horizons for new scientific discoveries. In turn, the openness of innovations gave impetus to the promotion of scientific projects developed within the framework of open science. Thus, "Living Labs" are implemented for the development of open science and open innovation within the university. This is reflected in the results of our study, since the data we process shows an increase in publication activity, interest in grant competitions, and an increase in the university's interaction with other members of the scientific community.

Based on the methodology on innovation activity monitoring proposed by the university of ITMO, we carried out a comprehensive multi-criteria analysis of interaction mechanism effectiveness. The calculation was carried out on the basis of forecast estimates made by extrapolation of retrospective data for five years (scenario A) and using an expert method (scenario B). As a result, we revealed that the proposed interaction mechanism should contribute to the increment of the innovative indicators of the university and, as a consequence, the development of an innovative economy. Thus, our hypothesis about the positive influence of the proposed mechanism on the interaction between innovation system actors and an increase in the effectiveness of the innovation activity of the university was confirmed.

The indicator of the level of effectiveness of interaction in a broad sense reflects the level of demand for goods and services created by the university, using the latest achievements of science and technology from the participants of the external environment. This indicator is an important indicator of the effectiveness of the three types of innovative activities of the university and its calculation will allow the success in each of these areas to be controlled, in particular the effectiveness of commercialization.

6. Conclusions

Nowadays, in Russia, the level of interaction between universities and other innovation system actors is low, the sphere of innovations is developing at a slow pace. The presented research is aimed at developing a mechanism for multilateral interaction between universities and other participants in the innovation system, which ensures the activation of scientific and innovative activities, acceleration of the transfer process, and effective commercialization of innovative ideas. To prove the positive influence of the proposed interaction mechanism we calculated the effectiveness of the university innovation activity using the validated methodology. The conducted study revealed an increase in all the university's innovation activity indicators due to the implemented interaction mechanism.

The practical significance of the work lies in the possibility of using the authors' developments in the practice of managing the innovation activities of universities to achieve significant results.

Limitations of the Present Study and Suggestions for Future Research

The theoretical work of other scholars in this field has been a useful resource for planning and designing, and we expect that our study will provide something of value for future researchers, too. Of course, there are some limitations in our study, as we evaluated the influence of the interaction mechanism based on an online platform of open innovations only on indicators of the Institute of Physics, Nanotechnology, and Telecommunications of Peter the Great St. Petersburg Polytechnic University. Additionally, the positive influence of the interaction mechanism was revealed due to forecast evaluations as the actual values of the indicators were not obtained at the time of the experiment.

In our further research we are going to compare the actual data of 2020/2021 and the forecast values we obtained in the current study, as well as analyze the entrepreneurial and innovative competencies of the university's researchers and ways to develop these competencies.

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Appendix A. Survey on Forecast Indicators of University's Innovation Activity

Dear participants!

The questionnaire is aimed at carrying out a predictive assessment of the indicators of the university's innovative activity after the introduction of an online platform of open innovations based on the "Living Laboratory" and "Networked Business Incubator".

It is necessary to analyze 12 indicators in 4 blocks. Please indicate the forecast indicators in accordance with your opinion in Table A1. Before answering, please read the data for 2015–2019 (university innovation activity indicators):

Table A1. Survey on Forecast Indicators of University's Innovation Activity.

№	Indicators	2020	2021
	Publication activity		
1.	The number of publications per scholar (Russian base)		
2.	The number of publications per scholar (WoS)		
3.	The number of publications per scholar (Scopus)		
4.	The number of publication citations (Russian base) per scholar		
5.	The number of publication citations (WoS) per scholar		
6.	The number of publication citations (Scopus) per scholar		
	Interaction with External Participants		
7.	The number of laboratories created by third-party organizations based at the university (participation in clusters)		
8.	The share of R&D financing under contracts with business entities in the total volume of R&D		
	Grant Activity		
9.	The number of applications for federal grants		
10.	The amount of R&D financing by grants in one research and development work (thousand rubles)		
	Intellectual Property		
11.	The number of RIA created with legal protection		
12.	The number of patents in collaboration with companies		

Appendix B. Survey on Weight Value of Innovation Activity's Indicators

A Survey of Experts Within the Framework of the Methodology for a Comprehensive Assessment of the Effectiveness of the University Structural Divisions' Interaction with Actors of Innovative Activity

Expert opinion is intended to determine priorities between indicators of publication activity, interaction with external actors, competitive activity, and indicators of intellectual property, as well as between their constituent areas within each of the listed indicators. Therefore, you are offered a two-step completion of the tables below.

In the first stage, it is necessary to arrange the weights in Table A2. Each of the four blocks is assigned values from 0 to 100%, in accordance with the degree of influence exerted by each block on the resulting indicator (interaction with innovation actors).

Table A2. Composition of the indicator of the effectiveness of the structural units' interaction with each other and with innovative actors in the field of innovation.

Indicator	Type of Innovation Activity	Weight Value, %
Effectiveness of university interaction with innovative actors	Publication activity Interaction with external actors Grant activity Intellectual property Total	 100

At the second stage, for each of the types of innovation activity, it is necessary to arrange the weights for a number of indicators detailing the elements of innovation in each of the blocks. The total sum of the entered values within one type of activity must also be 100%.

The first block is "publication activity" (Table A3).

Table A3. The composition of the block of publication activity indicators.

Indicator	Areas of Work Being Implemented	Weight Value, %
Publication activity	The number of publications per scholar (Russian base) The number of publications per scholar (WoS) The number of publications per scholar (Scopus) The number of publication citations (Russian base) per scholar The number of publication citations (WoS) per scholar The number of publication citations (Scopus) per scholar Total	 100

The second block is "interaction with external actors" (Table A4).

Table A4. Composition of the block of indicators of interaction with external actors.

Indicator	Type of Innovation Activity	Weight Value, %
Interaction with external actors	The number of laboratories created by third-party organizations based at the university (participation in clusters) The share of R&D financing under contracts with business entities in the total volume of R&D Total	 100

The third block is grant activity (Table A5).

Table A5. Composition of the block of indicators of grant activity.

Indicator	Type of Innovation Activity	Weight Value, %
Grant activity	The number of applications for federal grants The amount of R&D financing by grants in one research and development work (thousand rubles)	
	Total	100

The fourth block is intellectual property (Table A6).

Table A6. The composition of the block of intellectual property.

	Areas of Work Being Implemented	Weight Value, %
Intellectual property	The number of RIA created with legal protection The number of patents in collaboration with companies	
	Total	100

Additionally: what sphere of experts do you consider yourself to be most? (Underline whatever applicable)

(1) Education
(2) Science
(3) Entrepreneurship
(4) Other: _____

References

1. Global Innovation Index. 2020 Report. Available online: https://www.globalinnovationindex.org/gii-2020-report (accessed on 22 September 2020).
2. UMultirank. 2020 World University Rankings. Available online: https://www.umultirank.org/ (accessed on 22 September 2020).
3. Barykin, S.; Kobicheva, A. Logistical approach to universities integration in the Russian innovation economy. *MATEC Web Conf.* **2018**, *170*, 01020. [CrossRef]
4. Chubin, D.E. Open science and closed science: Tradeoffs in a democracy. *Sci. Technol. Hum. Values* **1985**, *10*, 73–80. [CrossRef]
5. Varshavchik, E.A.; Galyautdinova, A.R.; Sedova, J.S.; Tarkhov, D.A.; Kobicheva, A. Comparative testing of algorithms for constructing an approximate neural network and finite-element solutions of the model boundary value problem. *J. Phys. Conf. Ser.* **2019**, *1158*, 042032. [CrossRef]
6. David, P.A. Common agency contracting and the emergence of "Open Science" institutions. *Am. Econ. Rev.* **1998**, *88*, 15–21.
7. David, P.A. Understanding the emergence of 'open science' institutions: Functionalist economics in historical context. *Ind. Corp. Chang.* **2004**, *13*, 571–589. [CrossRef]
8. Merton, R.K. *The Sociology of Science: Theoretical and Empirical Investigations*; University of Chicago Press: Chicago, IL, USA, 1973.
9. Vicente-Saez, R.; Martinez-Fuentes, C. Open science now: A systematic literature review for an integrated definition. *J. Bus. Res.* **2018**, *88*, 428–436. [CrossRef]
10. Sutopo, W.; Astuti, R.W.; Suryandari, R.T. Accelerating a technology commercialization; with a discussion on the relation between technology transfer efficiency and open innovation. *J. Open Innov. Technol. Mark. Complex.* **2019**, *5*, 95. [CrossRef]
11. Tacke, O. Open Science 2.0: How Research and Education Can Benefit from Open Innovation and Web 2.0. In *On Collective Intelligence*; Springer: Berlin/Heidelberg, Germany, 2010; pp. 37–48.
12. Chesbrough, H.; Vanhaverbeke, W.; West, J. *Open Innovation: Researching a New Paradigm*; Oxford University Press on Demand: Oxford, UK, 2006.

13. Chesbrough, H.; Bogers, M. Explicating Open Innovation: Clarifying An Emerging Paradigm for Understanding Innovation. In *New Frontiers in Open Innovation*; Chesbrough, H., Vanhaverbeke, W., West, J., Eds.; Oxford University Press: Oxford, UK, 2014; pp. 3–28.
14. Perkmann, M.; Walsh, K. University-industry relationships and open innovation: Towards a research agenda. *Int. J. Manag. Rev.* **2007**, *9*, 259–280. [CrossRef]
15. Baregheh, A.; Rowley, J.; Sambrook, S. Towards a multidisciplinary definition of innovation. *Manag. Decis.* **2009**, *47*, 1323–1339. [CrossRef]
16. Cresbrogh, H.W. *Open Innovation: The New Imperative for Creating and Profiting from Technology*; Harvard Business Press: Boston, MA, USA, 2003.
17. Nobelius, D. Towards the sixth generation of R&D management. *Int. J. Proj. Manag.* **2004**, *22*, 369–375. [CrossRef]
18. West, J.; Salter, A.; Vanhaverbeke, W.; Chesbrough, H. Open innovation: The next decade. *Res. Policy* **2014**, *43*, 805–811. [CrossRef]
19. Enkel, E.; Gassmann, O.; Chesbrough, H. Open R&D and open innovation: Exploring the phenomenon. *R&D Manag.* **2009**, *39*, 311–316. [CrossRef]
20. Bogers, M.; Zobel, A.K.; Afuah, A.; Almirall, E.; Brunswicker, S.; Dahlander, L.; Hagedoorn, J. The open innovation research landscape: Established perspectives and emerging themes across different levels of analysis. *Indus. Innov.* **2017**, *24*, 8–40. [CrossRef]
21. Chesbrough, H. *From Open Science to Open Innovation*; Institute for Innovation and Knowledge Management, ESADE, Science Business Publishing: Brussels, Belgium, 2015.
22. Uribe-Echeberria, R.; Igartua, J.I.; Lizarralde, R. Implementing Open Innovation in research and technology organisations: Approaches and impact. *J. Open Innov. Technol. Mark. Complex.* **2019**, *5*, 91. [CrossRef]
23. Bedford, T.; Kinnaird, Y.; Migueis, R.; Paolucci, E.; Vos, A.; Wijlands, B. *Role of Universities of Science and Technology in Innovation Ecosystems: Towards Mission 3.1*; White Paper; Cesaer: Lueven, Belgium, 2018.
24. Vicente-Saez, R.; Gustafsson, R.; Brande, L.V.D. The dawn of an open exploration era: Emergent principles and practices of open science and innovation of university research teams in a digital world. *Technol. Forecast. Soc. Chang.* **2020**, *156*, 120037. [CrossRef]
25. Schiuma, G.; Carlucci, D. Managing strategic partnerships with universities in innovation ecosystems: A research agenda. *J. Open Innov. Technol. Mark. Complex.* **2018**, *4*, 25. [CrossRef]
26. Carayannis, E.G.; Campbell, D.F. *Mode 3 Knowledge Production in Quadruple Helix Innovation Systems*; Briefs in Business; Springer: Berlin, Germany, 2012; Volume 7.
27. Etzkowitz, H.; Leydesdorff, L. *A Future Location of Research in a Triple Helix of University Industry Government Relations*; Springer: New York, NY, USA, 1998.
28. What Is a Living Lab? Available online: http://www.openlivinglabs.eu/aboutus (accessed on 22 September 2020).
29. Arnkil, R.; Järvensivu, A.; Koski, P.; Piirainen, T. Exploring Quadruple Helix. Outlining User-Oriented Innovation Models. *Final Report on Quadruple Helix Research for the CLIQ Project*. Available online: //http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.864.3864&rep=rep1&type=pdf (accessed on 5 September 2020).
30. Yun, J.J.; Park, K.; Yang, J.; Jung, W. The philosophy of "open innovation". *J. Sci. Technol. Policy Manag.* **2016**, *7*, 134–153. [CrossRef]
31. Formica, P.; Curley, M. *Exploring the Culture of Open Innovation*; Emerald: Bingley, UK, 2018.
32. Lee, M.; Yun, J.J.; Pyka, A.; Won, D.; Kodama, F.; Schiuma, G.; Park, H.; Jeon, J.; Park, K.; Jung, K.; et al. How to respond to the fourth industrial revolution, or the second information technology revolution? Dynamic new combinations between technology, market, and society through Open Innovation. *J. Open Innov. Technol. Mark. Complex.* **2018**, *4*, 21. [CrossRef]
33. Yun, J.J.; Won, D.; Park, K. Dynamics from open innovation to evolutionary change. *J. Open Innov. Technol. Mark. Complex.* **2016**, *2*, 1–22. [CrossRef]
34. Yun, J.J.; Liu, Z. Micro-and macro-dynamics of Open Innovation with a quadruple-helix model. *Sustainability* **2019**, *11*, 3301. [CrossRef]
35. Yun, J.J.; Won, D.; Park, K. Entrepreneurial cyclical dynamics of open innovation. *J. Evol. Econ.* **2018**, *28*, 1151–1174. [CrossRef]
36. Coyle, D. *The Culture Code: The Secrets of Highly Successful Groups*; Bantam: New York, NY, USA, 2018.
37. Yun, J.J.; Zhao, X.; Jung, K.; Yigitcanlar, T. The culture for Open Innovation dynamics. *Sustainability* **2020**, *12*, 5076. [CrossRef]

38. Herzog, P.; Leker, J. Open and closed innovation-different innovation cultures for different strategies. *Int. J. Technol. Manag.* **2010**, *52*, 322. [CrossRef]
39. Edvinsson, L. The culture of Open Innovation—A new Twilight Zone? In *Exploring the Culture of Open Innovation*; Emerald: Bingley, UK, 2018; pp. 55–67.
40. Phillips, F. *The Conscious Manager: Zen for Decision Makers*; BookPartners: Charlestown, MA, USA, 2001.
41. Matricano, D. The State of the Art of Open Innovation Culture. In *Exploring the Culture of Open Innovation*; Emerald: Bingley, UK, 2018; pp. 139–162.
42. Yun, J.J.; Egbetoku, A.A.; Zhao, X. How does a social open innovation succeed? Learning from Burro battery and grassroots innovation festival of India. *Sci. Technol. Soc.* **2019**, *24*, 122–143. [CrossRef]
43. Klein, K.J.; Sorra, J.S. The challenge of innovation implementation. *Acad. Manag. Rev.* **1996**, *21*, 1055–1080. [CrossRef]
44. Technopolis Group & Mioir. *Evaluation of Innovation Activities*; Guidance on Methods and Practices; Study funded by the European Commission, Directorate for Regional Policy; Marielle Riché: Brussels, Belgium, 2012.
45. Bradley, A.; McDonald, M. *How to to Use Social Media to Tap the Collective Genius of Your Customers and Employees*; Harvard Business School Publishing: Boston, MA, USA, 2011.
46. Hausberg, J.P.; Korreck, S. Business incubators and accelerators: A co-citation analysis-based, systematic literature review. *J. Technol. Transf.* **2018**, *45*, 151–176. [CrossRef]
47. Eveleens, C.P.; Van Rijnsoever, F.J.; Niesten, E.M.M.I. How network-based incubation helps start-up performance: A systematic review against the background of management theories. *J. Technol. Transf.* **2016**, *42*, 676–713. [CrossRef]
48. Leydesdorff, L.; Perevodchikov, E.; Uvarov, A. Measuring triple-helix synergy in the Russian innovation systems at regional, provincial, and national levels. *J. Assoc. Inf. Sci. Technol.* **2014**, *66*, 1229–1238. [CrossRef]
49. Perkmann, M.; Tartari, V.; McKelvey, M.; Autio, E.; Broström, A.; D'Este, P.; Fini, R.; Geuna, A.; Grimaldi, R.; Hughes, A.; et al. Academic engagement and commercialisation: A review of literature on university industry relations. *Res. Policy* **2012**, *42*, 423–442. [CrossRef]
50. Sanyal, S.; Hisam, M. The role of business incubators in creating an entrepreneurial ecosystem: A study of the sultanate of Oman. *Int. J. Contemp. Res. Humanit. Soc. Sci.* **2018**, *7*, 60–77. [CrossRef]
51. Monitoring of the Effectiveness of Universities' Innovation Activity in Russia. ITMO. Available online: https://www.rvc.ru/upload/iblock/596/RVC_ITMO_05.pdf (accessed on 5 September 2020).
52. Plutchak, T.S. *OSI Issue Brief 1: What Do We Mean by Open? Open Scholarsh. Initiative*; Mason Publishing: Fairfax, VA, USA, 2018.