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Article

Updating the Open Innovation Concept Based on Ecosystem Approach: Regional Aspects

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Abstract: The intensification of innovation processes in Russia is a challenging task that requires a continuous search for solutions to make possible the many required changes in economics. We consider the major factors needed to advance an innovative activity at all levels in the national economy to have a freely exchanged flow of innovative ideas between all actors involved. As practice shows, the currently existing models in the country to deal with open innovations are mostly based on a cluster development approach, which is still limited. The authors propose synergizing the cluster approach with an ecosystem innovation model, which should ensure an effective collaboration and an accelerated rate for the diffusion of innovations between various actors while involving various regions. The purpose of the study was to develop a conceptual model for implementing open proposals from participants in the innovation economy. The research methodology is based on numerous works in the field of open innovation theory, cluster and ecosystem approaches. The study utilizes empirical and dialectical methods of scientific knowledge. The methodological toolkit covers information processing with historical analysis, a literature review using the Russian Citation Index and Scopus databases, analysis and diagnostics of innovative activity in domestic regions, the comparison method, modeling and correlation analysis. We concluded that the interaction of participants in the Russian regions through implementing the cluster model is not sufficiently effective and requires the development of new methodological approaches. Therefore, we propose combining the cluster approach with the ecosystem innovation model, which should ensure an effective cooperation and accelerate the rate of innovation dissemination among various subjects involving several regions. To determine the approach's efficiency, the proposed concept should be tested in one or more regions.

Keywords: innovation activity; open innovation; ecosystem; cluster; region; state; management; diffusion of innovation; Russia

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1. Introduction

One of the major factors of developing economics in the modern world is promoting innovation activities, which frequently ensures a competitive position of a state in the global market [1]. Thus far, the introduction of innovative high-performance technologies founded on scientific research has been considered to be a driver of economic growth that results in enhancing the welfare of a population [2]. Therefore, many states look for measures to support innovations [3].

Herein, the corresponding activities in regions play a significant role in the development and implementation of innovative ideas. This is especially true for the case of Russia, where the socio-economic development of individual subjects varies largely due to geographic and population differences [4]. Therefore, in order to ensure the innovative development of the state as a whole, it is necessary to focus primarily on the issues capable of intensifying activities in particular regions.

Currently, the innovative activity in Russian regions is clearly highlighted by a significant superiority of only the central regions, which serve as "points of growth" that are often supported at the federal level. However, as these points are rare ones, they cannot significantly manage the innovative growth of the entire state, accounting for its scale and territorial extent. Thus, there is a clear need to organize a regional's interaction, which could provide not only "free" innovation traffic but also appropriate support for the practical implementation of new ideas and their diffusion.

Here, we should consider the concept of "open" innovation, which has proven its efficiency and effectiveness in many countries [5] and is based on the ecosystem approach at the regional level [6,7]. This yields a promising positive effect via the fast transfer of innovations and their implementation due to the enhanced interest of all the actors involved and thus promotes a high output of innovative activities in subjects, regions and states as a whole.

In Russia, the realization of the concept has not been widely adopted, despite numerous states' efforts to promote a "seamless" innovation environment. However, in this country, the spread of these models could produce a synergistic effect, first, via ensuring the "accessibility" of innovative ideas, and, second, via speeding up the development and implementation of innovations. This direction requires an appropriate decision regarding the development of the architecture and content of the innovation ecosystem at the regional level as a component of the national innovation system.

The analysis of the theory and Russian practice of disseminating innovations at the meso-level shows that the existing models are not effective in reducing the innovative activity of the regions. Until now, the most effective model of interaction between participants in innovation processes has not been found. The emphasis is given only to some, mainly instrumental, aspects of open innovation, while the concept as relating to the development of regions in this direction is still debated.

So far, there is no universal model of open innovation based on cluster and ecosystem approaches that, on the one hand, satisfies the needs and demands of the actors of the innovation process, and, on the other hand, contributes to advancing the level of innovative development in regions. Therefore, we propose a new conceptual model of open innovation at the regional level here and highlight the importance of the management company, whose functionality primarily includes intensifying the transfer of innovations among all the actors.

Currently, the cluster model prevails as the major instrument in Russian practice to advance a level of innovative development in the regions. However, in our opinion, several fundamental problems arise in the framework of such a practice, including (i) a limitation of cluster members by regional borders; these cluster borders "close" the region regarding interacting with the external environment and (ii) the huge land scale, which makes real/physical interactions among actors in the economy of clusters rather difficult.

For the second point, let us refer to, as an example, the current inter-cluster interaction between the amber industry in the Kaliningrad region and the gold mining industry in Yakutia. Indeed, both participants of these clusters would benefit from the interaction. It would likely bring added value to the involved regions because the industry is unified, the targets and principles are similar, and innovations would follow mutually beneficial directions. However, the interaction is almost impossible now due to the spatial remoteness.

In this regard, we propose an updated model for implementing open innovation regarding the interaction of actors in the framework of an innovation economy. This model is based on the complementary synergistic interaction of cluster and ecosystem approaches to intensify the development of Russian regions. To achieve this goal, it is necessary to solve the following tasks. Task (1) is to conduct a content analysis on the "innovation" and "open innovation" terms in two scientific databases: Scopus and RSCI (Russ. Sci. Citation Index).This analysis is justified by the necessity (1.1) to define and to compare the "starting point" of the publication activity in the area by domestic and foreign researchers in order to determine existing gaps; (1.2) to identify and to compare the level of elaboration

of theoretical and practical issues in the scientific research via estimating the number of publications; (1.3) to clarify a share of open innovation research in the total research volume regarding innovations and to analyze how interesting the model of open innovation is for researchers; and (1.4) to consider and to define the features of the concepts of "innovation" and "open innovation" according to characteristics.

Task (2) is to analyze the formation of clusters in the Russian regions and to stretch a relationship between the presence of a cluster in the region and the level of Russian regional innovation development. Task (3) is to substantiate the need for further developing a conceptual model of open innovations accounting for cluster and ecosystem approaches. To solve this task, it is necessary (3.1) to consider and to compare the experience of employing the open innovation model in countries which are similar in several parameters to Russia; (3.2) to clarify the factors that delay a "re-flowing" of open innovations based on the experience of digital platforms; and (3.3) to substantiate the necessity of applying the diffusion model. These tasks configure the entire structure of this contribution.

The considered model, which is proposed as a way to implement open innovations, calls for expanding the research field into the interaction of actors involved in the innovation process at the meso-level. The scientific hypothesis of the current study assumes that one of the major directions for enhancing the innovative development of regions should be an implementation of an open innovation model, which is based on the synergetic interaction between the cluster and ecosystem approaches and mediated by a management company. As a result, we should expect a faster flow of innovative ideas, developed and implemented by participating actors, that would directly ensure advancing the level of innovative activity in regions and, thus, their socio-economic development.

2. Literature Review

In general, the major elements of the ecosystem include capital, know-how and subjects [8]. In our opinion, know-how is not the most effective mechanism for the commercialization of innovations, because it is utilized within a particular enterprise, which monopolizes it under protection, either by a trade secret regime or by a patent. Therefore, know-how is almost unacceptable for an ecosystem, whose distinctive feature is the exchange of innovative ideas in a framework of open innovation. Rather, the know-how that subjects guard within their enterprise relates to closed innovations. Therefore, the mechanism of technology transfer and commercialization should involve, in our opinion, mostly the patents. Some authors consider the actors involved in a triple helix as ecosystem subjects while adding "a science" [9]. However, it is not entirely correct to "tear off" a science into a distinctive subject since universities initially perform both educational and scientific functions; however, it is still right to strengthen and to pay more attention to the scientific function of domestic universities. The tetrad proposed in Ref. [9] looks like a closed chain, where an interaction between science and education, as well as between the state and business, does not have direct links, and the interaction goes through other actors. This concept is incorrect for an ecosystem, where all the actors should interact via direct personal connections.

The trend in the literature published by domestic authors in Russia considers the ecosystem under certain areas of activity; see, for instance, [10]. While taking an educational system in Ref. [11], the authors propose the major properties of its environment, which allow us to conclude that universities could be considered as an ecosystem. However, unlike the innovation ecosystem, the educational one does not involve a commercial benefit for the actors. Nevertheless, the proposed properties properly characterize and arrange the educational environment as an element of the innovation ecosystem.

The necessity of studying universities as one of the major actors in the ecosystem, while implementing the open innovation approach, is further emphasized by the authors in Ref. [12] who consider a platform for the exchange of output products as the basis for "open innovation". However, the ecosystem underlies an exchange of ideas and intellectual properties. Following this exchange of knowledge, all the actors could only produce output

products, which contradicts the suggested view. Moreover, the products are mostly the subject of a market economy while the ecosystem is an innovative one, where the results are not fully guaranteed. The further gap here is an absence of non-profit organizations, such as associations and unions, among the actors, which are now beginning to occupy a large niche in the ecosystem. Furthermore, these authors classify actors of the ecosystem into three categories: niche, dominant and "core" ones. However, the ecosystem is a constantly varying system where the places of actors involved change quite quickly. In our opinion, such a classification suits more innovation clusters, as further confirmed by the authors' reasoning.

An interesting viewpoint is given by Akberdina and Vasilenko [13], who highlight various areas in the innovation ecosystem. For example, they distinguish a theory of an innovation ecosystem, a regional innovation ecosystem, a university innovation ecosystem, etc. Such a fragmentation of the ecosystem, in our opinion, could be applied to any actor, not only at a meso-(regional) level but also at the state or even at the global level. In another study, Lyulyuchenko shows [14] that successful development of the ecosystem and the application of open innovation at the regional and industry levels depend to a higher degree on digital platforms in frames of the growing digital economy. We fully share this viewpoint. However, the proper identification of actors in the ecosystem, such as society, the state, science and businesses, is not supplied with mechanisms of their interaction. Furthermore, Tomilin et al. [15] studied industrial enterprises as major actors in the ecosystem to clarify the organizational culture of their activities. This is indeed worth studying to determine the internal environment of each actor to understand the goals, motives and reasons for possible resistance to taking part properly in the ecosystems. The results confirm that successful development of both the clusters and ecosystems requires support from the region in order to accelerate bringing innovations to consumers. In this direction, Borovskaya et al. consider [16] in detail another actor of the ecosystem, science and education, under the single term of "academic world". They consider three groups of the academic world, students, teachers and administrators, involved in the innovation process, but their interaction with the external environment is not described as matching the open innovation concept.

Orekhova and Misyura further hypothesize [17] that the ecosystems depend not only on the mechanism, where "strong" actors help "weak" ones to develop, but also on a higher demand for products and other conditions. Indeed, stimulations of the growth of ecosystems are numerous and based on the internal needs of the actors and the external environment's impact. However, in our opinion, the major driving reason is still the personal financial benefit for each of the participants, who are dependent on the vector of development within their field of activity.

Ovchinnikova and Zimin indicated [18] the existing gaps that impede more efficient development of the ecosystem in Russia, where the focus shifts towards state support, considering the core participants only. Here, other factors, which include the entrepreneurial environment and culture, the readiness of society to accept innovations, etc., are not accounted for. The authors tried to analyze these issues in relation to the entrepreneurial ecosystem, but similar gaps appear in the innovation ecosystem, too. The necessity of analyzing the perception of innovations by a population is further confirmed by Pishniak and Khalina [19]. These authors managed to draw up a "portrait" of domestic representatives of society, ready to try and use innovative developments, who are "young, educated, successful people without a fear of new technologies".

Babikova and Fedosova consider [20] the bottleneck in the interaction between the state and business structures, which leaves the question of who is a source of innovation and who is a consumer of innovation in this chain. Here, the innovation ecosystem cannot be considered without the actors, which supply a source of innovation.

Thus, there is a need to fulfill the existing gaps in functioning ecosystems in Russian regions, accounting for the literature yielded by various domestic authors. In summary, it is possible to group the existing discussions and gaps in this subject according to domestic

practice into four directions: (i) the need for more stable and transparent links between ecosystem actors; (ii) an understanding about the major actors and the mechanism of their interaction; (iii) the protection of objects of intellectual property; and (iv) a managing center, which could generate and accelerate the processes of an innovation exchange.

3. Innovative Activity in Russia and Its Regions

The recent rating results in the metrics of global indices, for instance, by the Global Innovation Index (GII), reveal that Russia took in 2021 45th place out of 132 countries [21]. This indicates a rather low level of innovative development in the country, which has been observed for years; over the past five years, there have only been some slight changes by one to two positions; for instance, it was in 46th place in 2018, 47th place in 2020, etc. According to the GII report, such a position was supported by human capital, a level of fundamental science/higher education, the positions of Russian universities in the QS ranking, the number of employees in science-related industries, the number of patent applications and the citation index. All the listed factors are based on the "places of origin" of innovative ideas, while the possibility of their practical implementation and, accordingly, the effectiveness of innovative activity, is determined by other indicators, which are valued far less compared to leaders. Primarily, these factors belong to the development of businesses, the market and infrastructure. In other words, the conditions under which the results of scientific research can be practically implemented are quite limited. This is also confirmed by the results of the Global Entrepreneurship Monitoring, which indicates a significant lag of Russia behind economically leading countries in terms of introducing scientific and technical developments and their employment into the practice of small and growing companies [22]. At the same time, despite the observed positive dynamics in the growth of new start-ups (the number of early-stage enterprises is 1.8 times higher than the number of established ones), their bankruptcy is much more likely in the period of up to five years of existence.

In terms of the effectiveness of innovation activity, Russia is still significantly inferior to the leading European countries. While the share costs spent on innovation activities in Russia is not significantly lower compared to leading countries, at around 2.1% (for comparison, this is 3.8% in Sweden, 3.3% in Denmark and 3.1% in Germany) in the total volume of shipped goods, performed works and services, the share of industrial enterprises engaged in technological innovation is only 9.1% [10]. At the same time, this figure in the leading European countries ranges at the level of 60–70%, being 72.6% in Switzerland, 71% in Norway, 68.1% in Belgium, etc. [23]. Similarly, the domestic share of innovative goods, works and services in total volume is quite low at about 5.3% when compared to Europe, where this ratio is characterized by the 17–20% range [10].

Nevertheless, the industrial enterprises in Russia spent, for innovative activities, approx. 1.6% of the total volume of shipped goods, works and services, comparable with the leading European countries [24]. Altogether, however, according to the Startup Ecosystem Rankings Report 2020 [25], which tracks the major trends in start-ups of ecosystems in various countries, Russia ranks 17th, significantly behind the USA, Great Britain and Israel, the leaders in this rating.

Thus, the overall picture of innovative development in Russia is currently not so exciting; despite the relatively high investments in innovation activities, its effectiveness remains low. One of the reasons for such a disparity seems to be a lack of necessary conditions to practically implement the results of scientific and technical developments. Therefore, we have to primarily look at the regional systems, which generate and implement the innovative ideas.

It is noted by many authors that the level of regional development throughout the country is highly varied due to a number of significant indicators. We may note Moscow, St. Petersburg and Tatarstan as leaders in the ratings of innovative development of regions [26]. Altogether, the top ten regions generate about 57% of the total volume of shipped innovative

goods, completed innovative works and services in 2020. Thus, the remaining 76 regions produce only 43% of the results of innovation activity.

It should be noted that the regions which ended up the list also have a low level of socio-economic status. Once again, this substantiates the theory that a high level of scientific and technological development largely depends on the quality of life, social aspects and economic well-being. In addition, a strong aberration between the leading and outsider regions is also caused by geographical and historical factors. As a result, high-tech industries and the scientific sphere are poorly developed in some areas of Russia. In particular, a recent analysis of opportunities to develop a high-tech business in the regions of Russia confirms the above [27]. Accounting for the share of regions with the resources to support a high-tech business and its performance, the highest score was assigned only to the central regions in Moscow and St. Petersburg. It might be noted that Nizhny Novgorod, Sverdlovsk and Tatarstan were highly rated, too.

Therefore, we may distinguish, say, five "growth points" in the context of innovative development in Russia. Under no changes in policy, an "innovative breakthrough" is not expected in most other regions that might significantly slow down the integral development of the domestic economics and its transition to the next technological mode. It is clear that ensuring a "leveling" of most regions is of primary importance to allow a necessary frame to form a national innovation system.

In order to prevent the current negative trends and to ensure a transition to a growth rate of innovation activity, it is necessary to encourage a transition from the traditionally established approach to the implementation of innovation activity and turn to an international practice that has proven itself to be effective, while taking into account national-level specifics. One of these directions, which is the focus of numerous current scientific research, is the concept of open innovation, which is actively implemented in economically leading countries.

4. The Concept of Open Innovation in Domestic Science and Practice

The theory of open innovation dates back to the 1990s, for instance to 1999, when an annual number of worldwide publications in this area exceeded 100. It continues to be a popular one now, given the wide opportunities and prospects for providing innovation diffusion and transfer. The analysis of the Scopus database showed that the number of publications in the XXI century (2000–2021) with the keyword "open innovation" amounted to 23,309 (Figure 1a), with 4478 publications in 2000–2010; since 2010, the annual number has exceeded 1000. The number of publications appearing annually in the last 11 years has doubled from 1015 in 2010 to 2495 in 2021. We compare the publication trend in Figure 1a regarding not only the "open innovation" keyword but also "innovation" in general. For instance, the "open innovation" papers amounted in 2000 to 99 or approx. 1:50 to total "innovation" ones, which reached a total of 4940. In 2005, this ratio was reduced down to 1:28 and reached the value of 1:16 in 2021. This feature displays a positive dynamic explained by a growing interest of researchers in "open innovation".

The leaders of the publications are located primarily in the USA, Great Britain, Germany, China, Italy and the Netherlands (Figure 1b,c), which are known to have support, including governmental support, in promoting innovation activity. The particular analysis of data drawn in Figure 1b,c shows that the leading country in 2000–2010 in "open innovation" was the USA with 1212 publications, or a ca. 27% share, which also maintained the lead in 2011–2021, tripling this number, though with a lower share of ca. 20%. For comparison, over 22 years, the UK maintained a ca. 10% share in the total number of publications with the absolute number being equal to 430 (2000–2010) and 1914 (2011–2021), or a 4.5 gain.

Sharper dynamics are observed in China and Italy in terms of the number of publications and their share. In China, the share increased to ca. 9% in 2010–2021, compared to ca. 5% in 2000–2010; the number of publications increased by 6.8 times. In Italy, the share reached ca. 8% in 2011–2021, compared to ca. 4% in 2000–2010; the number of publications

increased by 7.5 times. Obviously, the noted trends have been promoted by a general global tendency to support research in this direction. Such global dynamics suggest that open innovations find increasing interest in the academic society due their potential as a field of research.

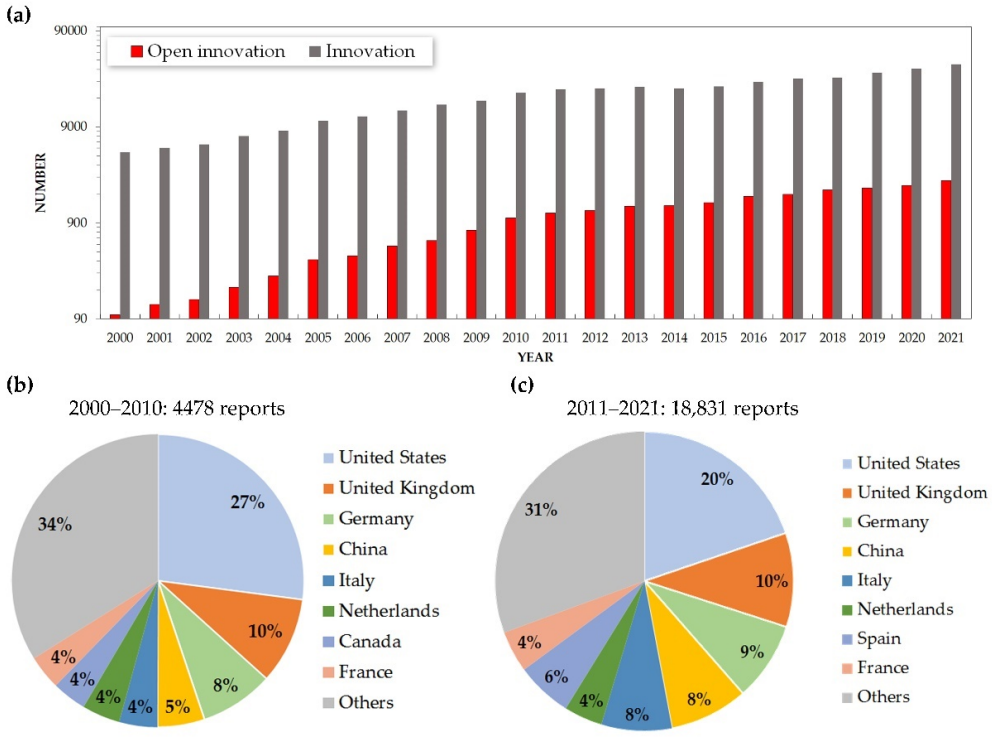

Figure 1. The publications in journals indexed in Scopus database for 2000–2021 period; a search was performed with "open innovation" and ''innovation" keywords: (**a**) the annual distribution of publications over the years; (**b**,**c**) the percentage distribution of country affiliations for the publications with "open innovation" keyword in 2000–2010 (**b**) and 2011–2021 (**c**).

According to H. Chesbrough, the founder of the theory of open innovation, companies should use targeted inflows and outflows of knowledge, which promote the commercialization of innovative technologies and expand sales markets [28–30]. In other words, the concept of open innovation implies using a conventional linear model implementing the stages of the innovation process via involving third-party "carriers" and "implementers" of innovative ideas. To single out the most important features of "closed" and "open" innovation, we introduce Table 1.

Based on the presented data, we may distinguish between advantages and disadvantages of open and closed innovation models. The disadvantages of closed innovation include (i) risks of underutilization of the ideas due to a lack of one's own resources, and (ii) the risk that the results coming from scientific activities within the company will not correspond to the business model or will be difficult to implement. At the same time, the major advantage of "closed" innovation is that the research within the company aims to achieve specific results, which makes it possible to create an innovative monopoly with a large profit [31]. On the hand, the advantages of the open innovation model are (i), expanding the geographical and institutional boundaries of innovative developments, (ii) reducing financial and time costs for the development of innovative technologies, (iii) obtaining more options to develop innovative products due to greater coverage by stakeholders, (iv) more opportunities for the exchange of innovations among various industries, (v) improving the accuracy of marketing research and customer focus, (vi) enhancing the interest of the target audience of the company through interaction during product development, and (vii) promoting interaction with consumers during the early stages of the innovation process. Despite the number of positive effects of implementing the open innovation

model, there are still inherent disadvantages. The major ones to note are (i) the higher risk of violation of intellectual property rights, (ii) a necessity of sharing an income with contractors and (iii) the high risk of dropping a viable innovation which is not profitable to implement at a given time for any reason [32].

Table 1. The comparison between the concepts of "closed" and "open" innovation in terms of major characteristics.

Characteristic	Closed Innovation	Open Innovation
Source of innovation	Internal R&D, in-house R&D	External R&D
Actors to generate innovation	Company employees	Universities, consumers, other companies, media
Use of intellectual property	Control of own intellectual property, prohibition of access of third parties to the use of intellectual property rights	Ability to use intellectual property of other developers; the possibility to transfer intellectual property rights Active interaction with contractors as a part of the commercialization process
Use of human capital resources	Use of human capital resources limited by place of work	Unlimited use of human capital resources
Method of intellectual property transfer	Vertical method	Horizontal and mixed method
Employed strategies	Implementation of the results of innovative activity in own production, creation of an internal venture, creation of an external venture	License agreement, franchise agreement, creation of strategic alliances, creation of joint ventures
Importance of going to market first	It is of paramount importance because the company, which brings an innovation to a market, primarily organizes an innovation monopoly	It is of a secondary nature because it is much more important to build an effective business model
Profiting from the results of intellectual property	Gaining profit from own results of innovative activity as a result of creating innovative products/technologies	Actively profit from granting intellectual property rights to third parties
Frontiers of innovative developments	Limited to the research company	Not limited; it is possible to use the results of innovation in other industries
Financial and time costs for the development of innovation	High financial and time costs	Opportunity to reduce time and financial costs by acquiring ready-made results of innovation activity

It is important to note that the shift of focus in the search for new ideas beyond the boundaries of an individual enterprise took place earlier, when the concept of open innovation emerged. For example, Cohen and Levinthal proposed the concept of absorption potential to consider the ability of an organization to identify and to use knowledge from an external environment [33]. In 1986, Klein and Rosenberg suggested a "chain model" for the innovation process, where sources of innovation, including external ones to the company, were identified [34]. The innovation system as interaction between subjects and institutions to develop and to implement innovations was considered by Freeman [35], Lundvall [36]

and Nelson [37]. As practice shows, many companies have carried out joint research and development works with external partners for many decades, and the outsourcing of research and development has been taking place for more than a hundred years.

At the same time, the concept of open innovation is currently widespread thanks, among other things, to the generalization of best practices in managing large international Silicon Valley companies such as Xerox, Intel, IBM, Lucent, etc. The active diffusion of the idea of open innovation into theory and practice primarily comes from its direct compliance with the current requirements to be compatible with fast and complex processes under uncertain characteristics of the VUCA world. Indeed, the time spent on long-term projects to develop ideas is often too expensive for many companies and the results, which do not correspond to the profile and the strategies of the company itself at any period of time, cannot simply be "thrown away" or "forgotten" but must be implemented either through a sale or installing start-ups. In addition, an effective symbiosis with marketing and venture financing is carried out thanks to open innovations. Due to organizing the incoming and outgoing flows of innovative developments under mutually beneficial cooperation between "generators" and "users", the implementation of the open innovation concept allows one to significantly accelerate and "to reduce the cost" of the processes in order to bring new ideas into the market. This advances not only the efficiency of actors in these interactions, including optimization of their internal organization for scientific and research activities, but also yields a new impetus for the development of society as a whole.

While looking at the evolution of the development of the open innovations, we may note that the concept exhibits continuous growth, although it still requires improvement to meet new challenges. Initially, the main focus of open innovation research was on the resource aspect of companies [38], in the context of the strategic development of enterprises [39], and on the interaction with a community theory. The limitations to implementing this approach were also considered [40]. Later on, competence-based and network approaches began to prevail in theory due to the diversity, continuity and multidisciplinarity of innovation processes, as well as their cross-border and inter-institutionality under the exponential growth rate of society's needs [41–43]. Currently, the open innovation model is being further developed and applied to universities [44,45] and various industries [46–51]. Many approaches have been elaborated, including, for example, (i) a triple-helix model, (ii) a cyclical model of the systemic dynamics of entrepreneurship, (iii) a model dealing with various forms of management, (iv) models reflecting the stages and sources of the search for external innovation and (v) models based on various types of partnerships and strategic alliances, as well as the creation of joint companies, including those based on universities and research institutes [52–62]. In addition, the features and recommendations to introduce open innovations in large companies, start-ups, holdings and small and medium-sized enterprises have been considered [63–66]. Indeed, according to Chesborough's study, conducted in 2013, 78% of the world's largest corporations practice open innovations [67]. In particular, the most striking examples are companies such as Procter and Gamble, Philips and Elly Lilly, where employing open innovation technologies has significantly enhanced the efficiency of their activities.

It can be said that the growing interest in this concept is driven by fast-developing digital technologies, which have been extensively advanced recently due to the COVID-19 pandemic, as well as by the reduced life cycle of innovation, which requires accelerating the implementation of innovative products while simultaneously reducing the time for their development. These requirements are fully met by the concept of open innovation, which allows one to disseminate innovative technologies based on the principles of open research [68]. In particular, a number of advantages provided by the concept can be noted, such as:

- Expanding the geographical and institutional boundaries of innovative developments;
- Reducing financial and time costs for the development of innovative technologies;
- Obtaining more options for the development of innovative products due to a greater coverage of stakeholders;

- The opportunity to exchange innovations between various industries;
- Improving the accuracy of marketing research and customer orientation;
- Increasing the interest of the target audience in the company through interaction during product development;
- Interacting with consumers at the early stages of the process to create an innovation;
- Reducing financial risks in the development of new technologies.

Of particular importance is the positive manifestation of the concept in relation to small- and medium-sized businesses with a high level of inventive activity that are, however, limited in the possibility of their commercialization, while large private and public companies have financial, labor and information resources for this. Thus, the need for collective interaction between companies is increasing [69,70]. In Russian practice, the problem of interaction between the subjects of the open innovation model is felt most acutely to be determined by (i) many barriers in the form of the risk of losing an intellectual property, (ii) difficulties in the selection of partners, (iii) mental features expressed in the reluctance to spread their own technologies, and (iv) difficulties in integrating innovative developments. Therefore, the open innovations have not received yet a broad coverage in the country. It is also necessary to note the existing "gaps" in relation to the protection of intellectual property rights, which also prevents the timeless diffusion of the concept. Based on the analysis of domestic works in the field, we may outline the following issues, which have attracted much attention from researchers: (i) applying the concept while considering the country's realities [71]; (ii) the effects and efficiency of implementing the concept in domestic enterprises [72]; and (iii) technologies and tools for trying out the concept of open innovation [73].

The scientific literature actively studies the features of open national innovation systems in various countries [7,74,75]. However, the Russian practice slightly differs: many domestic authors focus mostly on the openness of innovations within the state [73,76,77]. This approach seems to be quite logical because an internal system of open innovation is necessary in order to open the borders of the innovation system to subjects outside of Russia, which currently does not exist. Therefore, the theory of open innovation in Russia began to develop later than one in the leading countries noted above. The first publications in journals included in the Russian Science Citation Index [78] date back to 2005. The papers published annually in Russian periodicals in the period of 2000–2021 with the keyword "open innovation" and ''innovation" are displayed in Figure 2. As one can see, the number of studies here is significantly less than those at the global level, amounting to only 767 publications on "open innovation" and 27,482 ones on "innovation", with the ratio of 1:36, which is still lower when compared to the whole international value. The publication activity in the "open innovation" area has been non-linear and has varied from year to year, with minor deviations, from 50 to 70 since 2010. Such low values show an underestimation of open innovation in Russian research. This may be due to (i) the unwillingness of the real sector of the economy to "accept" open innovations, (ii) the fact that many actors are afraid and are not ready to bring their results of intellectual activity (hereinafter, referred to as RIA) to the external market, and (iii) the presence of gaps in the domestic legislative framework for RIA protection while the interaction of acts is not clearly conditioned for using open innovation.

It is worth noting that increasing publication activity in domestic science is accompanied by a positive experience in the practice of Russian organizations in implementing the concept under consideration. At the same time, the state regulation of these processes prevails.

Back in 2011, the state corporations and companies with state participation were forced to develop innovative development programs with mandatory publication under an open access model. Currently, there are 60 such large companies in the mining, energy, space, defense, communications and transport industries, such as, for instance, Gazprom, Russian Railways, Rosatom and Rostec. According to a survey of 50 large Russian companies conducted by the consulting company O_2 Consulting [67], about 62% of these companies carry

out the technology transfers for the commercialization of scientific and technical groundwork (73%), attracting external resources (64%) and tracking technological trends (55%). That is why certain intensifications are requested from both sides, from scientists to reveal existing problems and to propose solutions, and from other actors to effectively promote a transfer of innovations. It is worth noting that the current domestic research, as a rule, aims mostly to assess the readiness of the enterprises for open innovation in correlation with emerging technological opportunities [79], developing algorithms for introducing the concept of open innovation [80], generalizing and developing management aspects of the corporate R&D system based on models of open innovation [81,82], analyzing the possibility of introducing open innovations in various business areas [83] and in domestic realities [84] and identifying institutional barriers to the spread of R&D through open innovation [85]. If we turn to the practice of implementing the concept of open innovation in the country, then, of course, one cannot predict the intensity of its process due to its relative youth. Nevertheless, there is already some experience demonstrating the readiness of domestic companies to interact with other actors in the development and implementation of innovations; for instance, it includes a government "call" to the largest business representatives in 2017 to start cooperation with small innovative enterprises and start-ups [86]. This is evidenced, in particular, by the results of a study conducted by the Foundation for the Development of Internet Initiatives on the implementation of open innovation tools in Russia, in which large domestic and international companies working in various business areas took part [87]. Today, many companies actively cooperate with start-ups through the use of pilot project launch programs, business accelerators and corporate venture funds via, for instance, scouting tools.

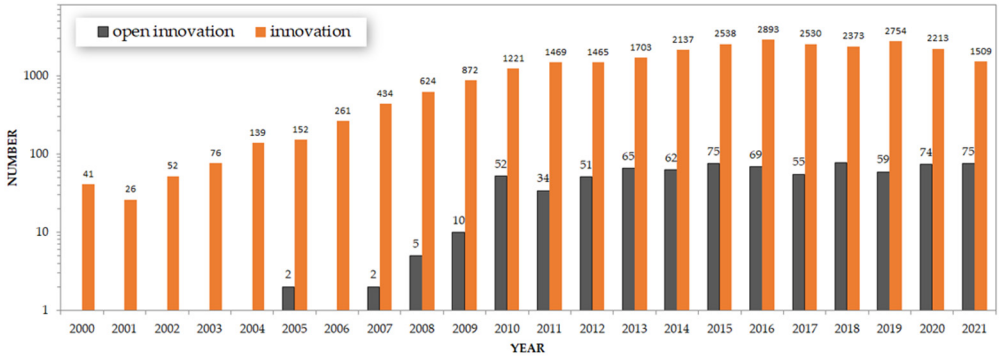

Figure 2. The number of publications appearing annually in scientific periodicals indexed in the Russian Science Citation Index in 2000–2021. Search was performed with "open innovation" and ''innovation" keywords.

At the same time, it was revealed that, as a rule, companies rely mostly on their "own options" while implementing open innovations; it is extremely rare to turn to technology parks and regional innovation sites for testing production equipment and real infrastructure, which reflects "unpreparedness" and inconsistency of the regional base and tools for the development of open innovations. Collaboration with other companies is often ineffective, reducing the efficiency of the search for innovations in regional markets and among foreign sources. Thus, employing open innovations in the country is concentrated mainly in large companies that prefer not to be sources of innovative ideas and technologies but instead their users. State-owned enterprises are similar to private ones, both implementing innovations and consuming innovative developments; however, in most cases, they cooperate with universities and research institutes [88].

It is obvious that the implementation of the concept of open innovation only at the corporate level is insufficient for the transition of the entire economy of the state to an innovation-type one, and one of the priority tasks in this direction should be expanding this model at the regional level. As stated in numerous domestic research works [89], "the introduction of the concept of open innovation in regional innovation systems is an urgent

and promising area of activity, which can significantly increase the competitiveness of the territory". At the same time, it is indicated that the authorities in many regions of the country focus on the importance of open innovation, which is reflected in the programs and strategies adopted for the development of the territory, such as the creation of platform foundations. We may note the platform for the interaction of industrial enterprises in the Perm territory, the Acceleration Program of the Republic of Mordovia, the IT platform of the Samara region and others.

Still, the question arises regarding how and with which tools the concept of open innovation can be implemented in the regions in order to obtain a fast but high-quality result within the limited timeframe.

5. Cluster as a Model to Implement a Concept of Open Innovation at the Regional Level

While considering regional innovation systems, one of the most popular current models used to employ the concept of open innovation is a cluster model, which considers the high importance of "territorial production associations in solving the problem of economic development of regions in order to enhance their competitiveness and innovation focus" [90]. The concept of clusters and their implementation in various countries was probably first considered by M. Porter [91] in 1990. Using the Italian shoe cluster as an example, he defined a cluster as "a group of closely related, supportive industries that creates a competitive advantage in a number of inter-connected industries to compete internationally." Further, the same author clarified [92] that a cluster should include a group of enterprises which belong to the same industry and are located in the same territory. The characteristic features of the cluster are (i) the maximum geographical proximity, (ii) the relationship of technologies, (iii) the commonality of the raw material base and (iv) the presence of an innovative component.

In Russian practice, the cluster concept is defined as:

- A set of special economic zones of one type or several types, which are directed by the government and managed by one management company (Federal Law "On special economic zones in the Russian Federation", 2005);
- Association of enterprises, suppliers of equipment, components, specialized production and services, research and educational organizations connected by relations of territorial proximity with a functional dependence in the production/ sale of goods and services [93];
- An array of industrial enterprises connected by relations of territorial proximity with a functional dependence should be located on the territory of one or more regions (Federal Law "On industrial policy in the Russian Federation", 2014).

Employing the given definitions, the characteristic features of a domestic cluster are a combined set of various organizations in a limited territory whose organization and infrastructure are frequently supported by a state via the development of a regulatory and legislative framework and incentives. In Russian practice, the definition of the cluster concept and the legislative basis for its development has only appeared recently. The domestic fundamental foundations in the field of clusters were established in 2008 through the introduction of the "Concept of long-term socio-economic development until 2020". The process of cluster formation began in 2012 when 25 innovative territories were approved for support in regions with high rates of production development and high scientific potential and competitiveness. Here, two major approaches are considered for the creation of clusters. In the first case, the state becomes an initiator through financial support for their development. Such a viewpoint has been supported by some authors [94]; however, this policy is not always successful, as shown elsewhere [95]. In the second case, the clusters are developed by transnational companies together with regions. This approach has been found to be more fruitful according to many authors [96].

It seems the understanding of these requirements resulted in significant support from the state, starting in the 2000s, which stimulated the regions to develop clusters for various

purposes within their territory. This state influence could be divided into direct and indirect influence. The direct participation of the state includes the creation of a legal framework for the development and protection of cluster policy, as well as direct financing in the form of subsidies, grants, targeted programs, etc. The indirect participation concerns such government activities as, for example, stimulating the formation of small innovative enterprises on the basis of educational and scientific institutions, which serve as a channel for the transfer of innovations from the academic environment to industry (Federal Law "On the introduction of amendments to certain legislative acts of the Russian Federation on the creation of economic companies by budgetary scientific and educational institutions for the purpose of practical implementation of the results of intellectual activity", 2009). The latter initiatives are supported by some authors [97], who view them as primary conditions to develop clusters and to transfer open innovations. It is worth noting that the recent hierarchical structuring of domestic higher education institutions by the government, which began in 2016, led to the introduction of flagship universities in the regions (Federal Law "On the competitive selection of educational institutions of higher education for the financial support of development programs of federal state educational institutions of higher education at the expense of the federal budget in 2016–2018", 2015). It was supposed that they could facilitate the formation of scientific and innovative centers to attract the most promising and talented youth, to reduce the outflow of young specialists from donor regions to large cities and to integrally stimulate the socio-economic development of the region.

Many authors employ the notion of the development of clusters within the framework of the triple-helix model proposed by G. Itskowitz [98]. However, this model has limitations in properly describing the experience of clusters in Russia due to a number of reasons. In particular, the conventional model of the triple helix yields the overlap area of the three participating actors, the state, universities and business, which are almost the same, which indicates equal participation of all the actors in the innovative development of the economy. In Russia, the state forms the basis and promotes a stimulus for the interaction between all the actors. Such a strong state influence is due to many fundamental reasons, which mainly include huge spatial territories, natural and climatic distinctions of the regions, a low population density in remote regions, the traditional propensity to a central power, an incomplete transition from an administrative command economy to a market-driven one, a lack of entrepreneurial experience among citizens, the instability of the national currency and the experience of defaults among the population, the low level of literacy among entrepreneurs in the financial and legislative spheres and the imperfection of the legislative framework developed so far. Therefore, the overlap area of almost all the actors in the domestic model has to be approximately equal to the area corresponding to the state. This implies the state is a major source, initiator and often driving force for the development of local industry, innovation and other clusters. Through the state basis, there is an interaction of other actors in the form of scientific and educational institutions, industry, business and society. Another feature of the country is that the bulk of scientific research is funded primarily by the state. The system of private universities in Russia is underdeveloped, and most of the universities are public ones with federal budget funding. Therefore, there should be no free zone in the model associated with the interaction of actors. This "zone of free interaction" is filled by the state.

Thus, by analyzing the domestic practice for implementing the cluster model, one can note the significant prevalence of the state's role in shaping the relationship and functioning of the actors in a territorial or sectoral association. In this regard, there is a negative limiting effect on the development of networks and cluster models [99]. As indicated, with such a model, the horizontal synergistic interaction between actors directly depends on vertical "top-down" management, which builds a network in accordance with its goals and interests and almost monopolizes the synergistic effects from the cooperation and interaction of actors in such structures [99]. In addition, the existing "bottlenecks" in the state policy regarding the innovative development, expressed in the insufficiently developed legislative

framework for the protection of intellectual property and innovative logistics, also impede the "free flow" of innovations and violate the principles of the open innovation concept. The possible solution in this case might be the development of a cluster model for the formation of innovative regional systems based on the application of an ecosystem approach, which ensures the implementation of the principles of harmonization and balanced innovative development of all the actors in the system, thereby contributing to the development of the domestic innovation system.

Currently, the state places a special emphasis on the role of clusters in the development of regions, as evidenced, in particular, by the numerous programs and strategies proposed for territories based on a cluster approach. For instance, in the case of the Nizhny Novgorod region, the strategy to develop Nizhny Novgorod Industrial Innovation Cluster in the field of automotive and petrochemistry sets the task "to ensure the openness of the territorial innovation system and economy, as well as the integration of territorial innovative companies into the global processes of generating and employing innovations". In addition, it is possible to refer to a number of successful examples introducing open innovations in some leading regions, such as the Platform of Interaction of industrial enterprises of the Perm region, the Acceleration Program of the Republic of Mordovia and the IT platform of the Samara region. The National Research University "Higher School of Economics" (hereinafter, HSE) collected a Russian cluster observatory providing information about Russian clusters. Based on the data of the observatory, we may analyze the formation and activity of clusters in the Russian regions. Figure 3 shows, for example, the number of domestic clusters that appeared annually over the period of 1999–2022. The figure indicates quite an inhomogeneous dynamic with a clear emergence of up to 27 clusters that appeared around 2014 that seem to have been obviously forced by the active federal subsidies implemented in order to support the cluster initiatives. Since 2016, there has been a clear drop in such support, which resulted in a slight reduction in clusters down to zero. Such a highly non-linear curve is totally driven by the state, which monitors these activities via the HSE. This university annually publishes analytical reports to follow the innovation activities in regions and lists their rating accounting for the so-called Russian regional innovation index (RRII). Currently, there are data published up to 2019 which consider various indexes grouped by such blocks as (i) socio-economic conditions for innovation activity, (ii) scientific and technological potential, (iii) innovation activity, (iv) export activity and (v) quality of innovation policy. It is still worth noting the absence of an index dealing with a cluster's existence and an analysis of its activity. Therefore, here we try to check the dependence of regional innovation development accounting for the RRII index on the local clusters, accounting for such indirect factors, such as the number of clusters and number of employees there. We have arranged all the regions in Table 2 according to alphabetical order with corresponding values of the noted factors and calculated their correlation to the RRII index.

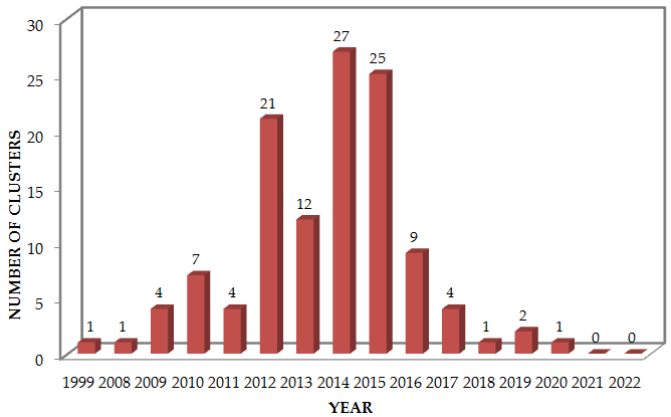

Figure 3. The number of clusters formed annually in Russia in 1999–2022 accounting for data provided by HSE.

Table 2. Distribution of regions in Russia with clusters; the data have been adapted from Refs. [26,100].

No	Region	Number of Clusters	RRII Rating	Number of Employees
1	Altai region	5	0.3313	20,929
2	Arhangelsk region	2	0.3473	70,537
3	Astrakhan region	1	0.3199	599
4	Belgorod region	1	0.3899	2498
5	Bryansk region	3	0.3193	766
6	Volgograd region	2	0.2901	58,043
7	Vologda region	4	0.3194	6896
8	Voronezh region	5	0.3783	44,399
9	Irkutsk region	2	0.3687	9865
10	Kaluga region	1	0.4178	11,259
11	Kemerovo region	2	0.3472	29,983
12	Kostroma region	1	0.2526	5116
13	Krasnodar territory, Moscow region, Moscow	1	0.3354	5892
14	Krasnoyarsk region	1	0.4272	29,048
15	Kurgan region	1	0.2463	4589
16	Leningrad region, St. Petersburg	1	0.3382	13,845
17	Lipetsk region	4	0.3752	34,633
18	Moscow	6	0.5508	111,145
19	Moscow region	3	0.4585	76,977
20	Murmansk region	2	0.3352	149
21	Nizhny Novgorod region	1	0.4813	5581
22	Novgorod region	4	0.3520	7542
23	Novosibirsk region	1	0.4303	22,335
24	Omsk region	3	0.3638	36,929
25	Oryol region	3	0.3284	1422
26	Penza region	4	0.3567	10,873
27	Perm region	3	0.3968	58,280
28	Republic of Bashkortostan	1	0.4017	49,094
29	The Republic of Buryatia	1	0.2956	10,711
30	Komi Republic	1	0.3334	3300
31	Republic of Mari El, Chuvash Republic—Chuvashia	1	0.3396	11,006
32	The Republic of Mordovia	1	0.3770	9866
33	The Republic of Sakha (Yakutia)	2	0.3091	166
34	Republic of Tatarstan	6	0.4984	207,227
35	Rostov region	9	0.3827	59,486
36	Ryazan Oblast	3	0.3756	5283
37	Samara region	2	0.4092	54,063
38	St. Petersburg	9	0.5304	116,090
39	Sverdlovsk region, Chelyabinsk region	1	0.4108	21,734
40	Sverdlovsk region	1	0.4266	27,276

Table 2. *Cont.*

No	Region	Number of Clusters	RRII Rating	Number of Employees
41	Smolensk region	3	0.3362	4499
42	Tomsk region	3	0.4922	24,286
43	Tula region	2	0.3955	42,170
44	Tyumen region	1	0.4266	2584
45	Udmurt republic	1	0.3160	36,211
46	Ulyanovsk region	2	0.4140	50,677
47	Khabarovsk region	1	0.3964	27,373
48	Khanty-Mansi Autonomous Okrug—Yugra	1	0.3180	2923

We calculated the correlation coefficient between a cluster's number and RRII index, achieving a value equal to 0.37, which is too weak to indicate a strong effect on the total innovation activity in regions. In contrast, the correlation between the number of employees in clusters and the RRII index was much stronger; the coefficient went up to 0.59. This result indicates the positive impact of a cluster's presence on the regional development.

Still, Table 2 does not take into account all the clusters available in the country. For example, there is a pharmaceutical cluster in the Yaroslavl region that appeared in 2016 which is not listed. It could just shift the correlation coefficient without heavily disturbing the reliability of the trend we observed.

Furthermore, a few more issues could be noted when analyzing the data presented in Table 2. First, the total number of regions in Russia was 85, but only 48 of them, or 55%, are listed in Table 2 as having clusters. This value is quite low. For comparison, France introduced in 2005 so-called poles of competitiveness under a program like the Russian one in terms of its goal and major strategic directions. In 2007, the number of poles there reached 71, with a density of ca. 1.3×10^{-4} sq. km^{-1}, which exceeds the current density of clusters in Russia, at ca. 6.96×10^{-6} sq. km^{-1}. Therefore, the innovative development of Russian regions requires a further analysis and possibly the intensification to account for various actors' collaboration. Second, Table 2 indicates that most clusters appear in frames of a single region while inter-regional ones are very rare and are mostly seen in the neighboring territories, such as Leningrad Region and St. Petersburg, the Republic of Mari El and the Chuvash Republic, and the Sverdlovsk Region and the Chelyabinsk Region. There was only a single cluster formed in 2017 in the Krasnodar region and the Moscow region including Moscow, which are located at a great distance from each other, under the management of the Moscow region. This suggests a high potential to accelerate the inter-regional collaboration, which is currently faced with a number of barriers. We suggest that developing clusters in an ecosystem model might facilitate further such interaction and "pull up" regions with a low level of innovative development based on the open innovation approach.

While the cluster model brings numerous advantages, such as (i) the generation of a technological network in the region, (ii) a high degree of specialization, (iii) reducing the cost of innovation and (iv) the possibility of developing in regions a framework of an integrated approach, there are also some significant drawbacks. For example, specialization in any area under a direct state's target makes the region vulnerable, and the isolation of actors within the cluster limits their interaction with the external environment, which prevents growing further ties. However, the most significant drawback, in our opinion, originates from the rigidity of the cluster structure, or the lack of its adaptability, which delays a response to changes in the external environment and its competitive challenges, which might even inhibit the region.

6. Implementing the Open Innovation Concept in Brazil, India and Canada for Comparison with Russia

To compare the Russian experience with some international ones, we could consider such countries as Brazil, India and Canada, which are closest with regard to territory. Additionally, Brazil, India and Russia have similar values in GDP (India took third place, Russia sixth and Brazil eighth in 2020) and in the innovation index (Russia was 45th, India was 46th, and Brazil was 57th in 2021). Furthermore, we agree with some authors [101,102] that the emerging economies of Russia, Brazil and India, have in common dominant public funding. Canada is quite interesting to consider, too, because it has, similar to Russia, (i) a clear distinction of two kinds of territory: one with developed infrastructure and a periphery one, (ii) the same focus of development for the sectors of agriculture, forestry, mining and oil mining and (iii) natural and climatic conditions.

6.1. Case of Brazil

According to Ref. [103], the state policy in the field of innovative development of Brazil's economy aims at achieving the synergy of all the actors in order to enhance the innovative potential of the market by combining small innovative enterprises with large ones, as well as stimulating the appearance of innovative enterprises through several indirect supports via, for instance, tax incentives. The literature shows [104] that start-ups are the major mechanism involved in introducing open innovation in Brazil. In this country, there are a large number of agencies, including non-profit ones, with the aim of accelerating implementing and applying innovations with clearly defined functions. A wide variety of programs stimulate the innovative development of enterprises in contrast to Russia, where the number of programs to support interaction of various actors via open innovation is quite limited and includes the Innovation Promotion Fund (1994), yielding eight programs, the National Technology Initiative (2016) and the Agency for Strategic Initiatives (2011). Still, the latter organization could not fulfill the government's directive to advance Russia from the 120th place to the 20th place in the international Doing Business rating of the World Bank by 2018. In Brazil, more attention is paid to the activities of innovative enterprises, both from the state and other sources of investment. In contrast to Russian practice, the investor's "assistance" consists not only in financing but also in providing the marketing services, patent services and interaction of actors in the innovation activities. Still, however, both Brazil and Russia have to improve the patent system. In Brazil, for instance, the registration of a patent takes up to 10 years, which obviously leads to a spillover of open innovations in the ecosystem, because the invention might lose its relevance over such a long period of time and bring no or a less-than-expected income. Still, the Russian patent agency takes a shorter time for such a registration, from 1 to 1.5 years, which might be considered to be a positive factor. Another acute problem in Brazil hindering fast development of the innovative enterprises is the lack of highly qualified personnel in IT technologies. This is completely different in Russia, which even serves as a donor of IT specialists at the global level.

It is worth noting that Brazil has an interesting solution to the problem of intellectual property rights, which a priori belong to public sector institutions. In Russia, the industries are not ready to employ intellectual properties, which do not belong to the enterprises. This greatly hinders the development of spin-offs. In contrast, Brazil fixed the practice of managing the transfer of the results of intellectual activities of the public sector to autonomous organizations at the legislative level in 2018. A quite remarkable example comes from Brazil's automotive industry [105], where a preference is given primarily to closed innovations via their own managing departments. As researchers note, the reason seems to be a misunderstanding of the open innovation approach by top industry managers. This is quite similar to Russia, as well. As a solution, it is necessary to develop a corporate culture and to advance the use of novel intellectual properties. Furthermore, some authors emphasize [106] that universities should be an innovative core of ecosystems. However, neither country has sufficient development in this direction. The same feature relates

to growing spin-offs, which occupy a certain niche in the development of ecosystems to transfer technologies.

In summary, we may conclude that one of the key factors in advancing an ecosystem in both countries is developing the region of interest; the proximity to the regions leading in innovative development is a positive factor, too. The periphery's economics is always characterized by a "catching up" nature and is thus unlikely to reach the leaders' status without proper support. The innovative resources are concentrated in a low number of central regions. Still, these two economies grow in different directions: the focus in Brazil has shifted to the export of engineering products, while Russia is a pronounced exporter of raw materials. Furthermore, a distinctive feature of Brazil's policy is attracting foreign companies. We believe Russia could adopt the Brazilian experience (i) to develop corporate multinational enterprises attracting venture capital to the regions of interest from external sources and (ii) to promote start-ups in accordance with current market needs via adopting artificial intelligence.

6.2. Case of India

The economies of India and Russia have a common feature insubstituting the import to a higher degree. To reach this target, the governments apply similar regulations, which makes it interesting to compare innovation policies.

Some authors note [107] that India has to intensify the interaction between entrepreneurial universities, industry and the state as a major factor for the country's development. Indeed, it occupies a leading position in financing research and development activities [108]. Somehow, implementing the concept of open innovations could be considered via creating a database to connect specialists in the field of innovation and young professionals to promote the exchange of ideas. This is practiced in Russia, too. Another similarity comes from a similar patent system in both countries; however, India now pays special attention to adapting the domestic patent regime to the international one in order to simplify employing results of intellectual activities. India mostly has state support for innovations, like Russia, which is quite vertical, provided by the state to research institutes, universities, incubators and other structures united in a single block.

Despite the priority participation of the state in the country's innovative development, India now actively attracts international venture investments through the formation of the Indian Association. Particular attention is paid to the development of technology parks and incubators, which are provided under tax incentives and other support measures [109,110]. Some authors find [111,112] India and Brazil to be quite close in their innovative development as they involve foreign capital and are highly different from Russia; the most remarkable example is Bangalore, Mumbai [113]. Furthermore, the attention in India focuses on advancing entrepreneurial ecosystems where business incubators and technology start-ups are in a central place [114,115]. In these systems, one of the major actors is foreign companies [116] such as Xerox Corp or Microsoft, which interact with other actors, such as domestic and foreign companies, universities, etc. It is worth noting that such a collaboration mostly takes place over the country's periphery, though the interaction between companies and universities is still low.

In conclusion, the ecosystems in India are focused on (i) an intensive development of the regions, in the central part of the country and beyond and (ii) active involvement of foreign partners for innovative activities. These practices could be helpful to Russia, especially regarding intensifying remote regions' activities via state support under conditions of limited involvement of foreign capital. Moreover, the involved actors should not compete for markets and resources but interact with mutual benefits.

6.3. Case of Canada

Primarily, we should note that in contrast to the previous two countries, Canada's economy is already developed [117,118]. However, despite this fact, the state actively participates in funding innovation activities. Still, the public funds are spent on such targets

as (i) improving the skills of employees because a low professional level is considered to be a weakness, (ii) developing superclusters and (iii) focusing on extending clean technologies by encouraging international alliances. A particular feature of the Canadian ecosystem is the employment of the concept of a "strategic bridge" as a mechanism for implementing open innovations. The government there pays special attention to strengthening the patent system; for example, it provides special care to protect results of intellectual activities from various imitations of the original.

Altogether, the innovation policy in Canada widely implements the concept of open innovation with a focus on the ecology issues and advancing innovative competencies. At this point, Russia still adapts Canadian practices to implement the open innovation model involving green technologies into a resource-based economy. We summarize the major characteristics of the innovation activity in the three studied countries based on published reports [105,106,119–121] in Table 3.

Table 3. Characteristics of the innovation activity in Brazil, India and Canada; the data have been adapted from Refs. [105,106,119–121].

Brazil	
Goals	Small and medium enterprises should take up a large share of the market; Strengthening cooperation between industry, universities and research organizations; Developing a digital infrastructure; Advancing research and development in priority areas of the economy; Creating competitive advantages to satisfy market needs.
Major contributors	Small and medium innovative enterprises; The state; Large industrial enterprises; Innovation providers.
Differences to Russia	Development and implementation of various specialized programs to stimulate the innovative activities of participants, such as Nexos; Small and medium enterprises are strategic partners; Formed legal framework in the field of innovation; Participation of the state bank in the creation and support of small and medium innovative enterprises; Allocation of grants and co-financing by the national innovation agency; Active patent support in the interaction both between enterprises within the state and in the international market.
Similarities to Russia	Strong state support; The patent system needs to be improved; A large proportion of R&D employees are busy in the public sector; Innovative enterprises have more partners from the industrial environment than from the academic and scientific ones; The need to intensify interaction between industry and academia to achieve a greater impact from open innovation; Development of the region based on available local resources.
Principles	Mutually beneficial cooperation; Active stimulation of innovation activity; Support for all the system actors.
India	
Goals	Import substitution; Attracting foreign companies to participate in the innovation process; Development of the entrepreneurial ecosystem.

Table 3. *Cont.*

Major contributors	Universities; Industrial enterprises; The state; International enterprises.
Differences to Russia	Active involvement of foreign enterprises in the country's innovation processes; Creation of hubs for system's actors.
Differences to Russia	Active involvement of foreign enterprises in the country's innovation processes; Creation of hubs for system's actors.
Similarities to Russia	Weak ties between government, industry and universities; Gaps in the patent system; Location.
Principles	Partnership; Globalization; Priority development of regions.
Canada	
Goals	Formation and encouragement of business culture; Innovation must be user-centric.
Major contributors	State; Private investors; Universities; Commercial professionals; Suppliers.
Differences to Russia	The priority is the development of new types of energy resources, renewable energy sources; The presence of various bodies, committees that support innovative research at universities; The presence of the "inventive" side of the innovation potential; Priority in the development of innovations is given to the team, and not to an individual; Mechanism of "living laboratories"; Close cooperation of all actors in the ecosystem.
Similarities to Russia	Low level of investment risk for enterprises; The main financial burden for the development of innovations in the academic and scientific environment is borne by the state; Weak connection between the scientific and educational environment and industry.
Principles	Innovation is the foundation of competitiveness; Greening economics.

7. A Conceptual Model of Open Innovation in Regions Based on the Ecosystem Approach

Currently, many researchers often appeal to the ecosystem model as a foundation to effectively develop regions able to produce open innovations [122]. This model is associated primarily with Tensley, Moore and Rothschild as the founders of the ecosystem theory in business and innovation aspects, and they are noted today even more often than Porter, Kondratiev and Schumpeter. Due to the great amount of research literature in this area, we will obviously not dwell on a deep historical analysis of the origin of the term "ecosystem". For the target of the present contribution, we would only note the important provision, inherent in ecosystems, according to which all its actors interact on the basis, by analogy, with a biological system, on the principles of self-organization and mutually beneficial distribution of resources. The innovation ecosystems are frequently defined as "a set of actors and connections between them for the mutual exchange of ideas and knowl-

edge" [123], "an emerging environment and conditions favorable for the development of technological entrepreneurship at all stages of the innovation process" [124], "a dynamic set of organizations and institutions and their multidimensional internal relations" [125] and "a new organizational integrity and a way of producing innovation" [126]. As stated, "the ecosystem approach considers innovation systems at all levels (national, regional, cluster, etc.) as living social organisms, subject to continuous variability, under the influence of new motivations of participants and new circumstances" [127].

At the same time, the researchers, as a rule, have an interest in finding how the actors interact in the creation and commercialization of innovation [128,129]. Here, issues related to the technology of interaction between actors are emphasized to ensure their mutual interest and the unhindered movement of all the flows accompanying the stages of innovative processes. At the regional level, the concept of an "ecosystem" is maintained to represent "a favorable environment for the commercialization of innovation and the intensification of innovative processes, based on the principles of self-organization and self-development" [130] while organizing mutually beneficial cooperation of all the actors is still within the scope.

As mentioned above, the "bottleneck" in the cluster model is often the "rigidity" and hierarchical management, which is implemented mostly by the state, which focuses on its own interests, thereby "suppressing" the certain interests of other actors. The ecosystem approach eliminates this drawback by providing the participants with the opportunity to "self-organize" and to "self-develop", which makes the structure more flexible and adaptive, while implementing principles for mutually beneficial distribution of resources acts as a motivator, too. Still, though, there are some disadvantages, which should be accounted for. For instance, it is indicated that the formation of the innovative ecosystem in regions cannot progress quickly since "the ecosystem is a constantly developing organism" [131]. In this regard, it becomes difficult to ensure an accelerated development. Secondly, "an ecosystem, unlike a classical company, is based on modularity, and not on hierarchical management, while there is a need for coordination and sharing of complementary resources and competencies" [132]. Therefore, as indicated, it is impossible to ensure the development of an innovation ecosystem without a special regulatory environment despite its key characteristics of self-organization, self-development and adaptability [133].

Therefore, we consider here a synergetic combination of the two models based on the benefits of cluster and ecosystem approaches. Figure 4 presents such a model for implementing the concept of open innovation. Herein, the actors [134] perform the transfer of innovations to the managing organization, which processes the obtained RIAs and then moves these results to the open innovation bank to ensure free access. Accordingly, the greater impetus is given through the management company to disseminate open innovation. Thus, the ecosystem approach, which initially drew attention due to differing from the cluster, network or "technopark" models in its self-organization and ability for self-development and adaptability, now obtains a control link in the system.

To properly organize such a control link, there are various options, including the state, a digital platform or a company [135,136], which constitute a "central entity around which the innovation ecosystem is built" [13]. In this context, we should employ the term "orchestrator" to denote the central subject of the ecosystem [137]. In addition, it is proposed to consider a "pacemaker" as a "center of intellectual attraction of actors", which ensures a consistency of the interaction of all the actors, (a separate actor, technology, project or platform, with each other [138]. Furthermore, Ramenskaya introduced the concept of an "ecosystem leader" which "sets the architecture and basic parameters—general rules and methods of interaction, standards, interfaces" [131].

Here, we should note that many research works consider a digital platform to serve as the link, which manages the interaction of the ecosystem's participants. However, such a link is justified in Russian science and practice by a real need for a control element which can combine into a single system and organize the interaction of its actors, as well as provide the necessary support for their initiatives, aiming to create and implement innovations.

Therefore, we suggest a model of the innovation ecosystem in a region, which accounts for elements of the cluster and ecosystem models in order to implement the concept of open innovation. With mutually beneficial and self-organizing interaction of the actors, the core element here is a management company implementing functions of managing and regulating the interaction of actors, as well as providing, if necessary, a methodology support in the application of technologies, methods and tools for the development and implementation of innovative ideas. In other words, the model combining education, business and state actors is complemented by a management one. At the same time, the management company must be also motivated, unlike the cluster model, to achieve the final result, which must be approved by a corresponding agreement among the actors. Given the existing trends, this model can be implemented in the digital platform, which does not change its concept and focuses on enhancing innovation in a region.

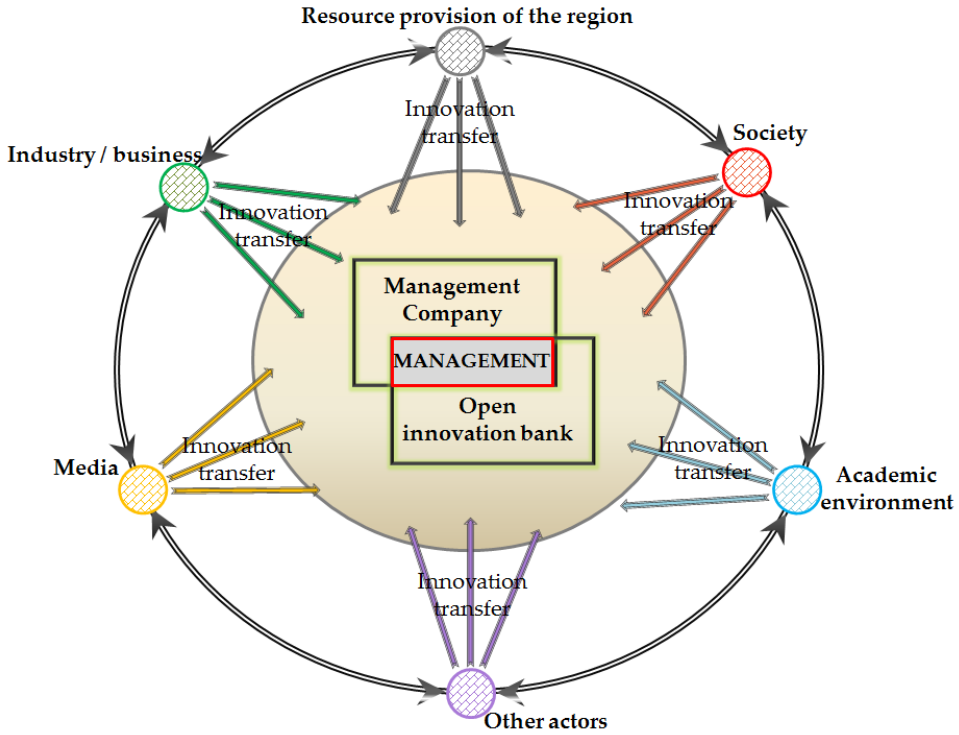

Figure 4. The schematic view for a model implementing the concept of open innovation based on the cluster and ecosystem approaches.

8. Discussion and Conclusions

To justify the efficiency of the proposed model for faster dissemination of innovative ideas, we could apply a diffusion model, which is widely employed for innovative processes based on fundamental approaches by Bass [139] and Rogers [140]. Rogers's model assumes that the rate of the innovation's dissemination directly depends on the number of potential consumers and the strategy's efficiency in promoting the product. In other words, the major emphasis is on the consumer's characteristics and their ability to perceive a new product. Bass further elaborated on Rogers's approach, accounting for inter-personal communication, which determines the extent to which the number of consumers of innovation increases due to the transfer of information regarding the innovation "by word of mouth". At present, Bass's model is widely adopted by many research works; see, for instance, [141,142].

In general, the diffusion model, taken as the initial one, is represented as [143–148]:

$$\frac{dF}{dt} = \left(p + q \times \frac{F(t)}{N}\right) \times (N - F(t)) \quad (1)$$

where $\frac{dF}{dt}$ is the number of new buyers/users of the product at the time t; $F(t)$ is the total number of those who purchased the product by the time t; N is the maximum possible number of potential buyers of the product; p is the parameter of external influences (innovation parameter) showing the "advertising effect"; and q is the parameter of internal influences (imitation parameter) showing the effect of communication.

By introducing the probability function as $f(t) = \frac{F(t)}{N}$, where $f(t)$ is the ratio of the total number of those who purchased the product to the maximum possible one of potential buyers, Equation (1) is formed as follows:

$$\frac{df}{dt} = (p + q \times f) \times (1 - f) \tag{2}$$

It is obvious that the boundary conditions under Cauchy's problem will be $f(0) = f_0$.

According to this approach, the number of buyers/users of an innovation is influenced by the advertising of the innovation and inter-communication among potential users. The major conditions for promoting a transfer of innovations to a greater extent are (i) the correspondence of innovative ideas to the current needs of society, (ii) the availability of information channels able to disseminate the information on innovations and (iii) the existence of organized and influential groups interested in disseminating innovations. It is obvious that these requirements are entirely satisfied by an innovation ecosystem. At the same time, the innovation ecosystem is distinguished by an absence of the effect of advertising, which cannot lead to increasing the number of consumers. Therefore, the coefficient of innovation, which depends on the effect of advertising, will be zero or close to it (p = 0). At the same time, the intensity of distribution to be governed by the interaction of the actors in the system is expressed via the imitation coefficient. Accordingly, Equation (3) takes the form:

$$\frac{df}{dt} = q \times f(1 - f) \tag{3}$$

This equation describes the simplest logistic curve, whose solving yields

$$f = \frac{1}{1 + \frac{1-f_0}{f_0} e^{-qt}} \tag{4}$$

where f is the number of new users/buyers of innovative ideas, f_0 is the total number of users/buyers who turned to innovative ideas within the ecosystem, and q is a simulation parameter expressing the effect of communication. The graph of the $f(t)$ function is a monotonically increasing S-shaped curve.

Taking into account the current situation in Russia, where most regions have low innovative activity, it can be assumed that the diffusion of innovations will have a rather sluggish character. It is reflected by a smooth section of the S-shaped curve, indicating the low penetration rate of innovations into the regions. The management company proposed within the framework of the model will contribute to faster connection between the actors, which, in turn, would further advance the effect of inter-personal communication and, accordingly, increase the dissemination rate of open innovations. In this aspect, the diffusion of innovations will be influenced by the characteristics of the information component inherent in social networks. Therefore, the diffusion should take into account the influence of inter-communication between the actors in the innovation ecosystem.

To date, there are several approaches, which describe the influence of inter-personal interaction of agents on the diffusion of innovations [146,149–155]. Following these works, the ecosystem appears as a certain social network with a number of actors, N, which interact with each other. Here, the rate of "infection" by open innovation will be determined by the degree of trust between actors, which should be properly encouraged by the management company that establishes their interaction. Taking into account the above, we may add the diffusion model by introducing the interaction function $n(t)$ of ecosystem actors. This function reflects a variation in the number of users of innovative ideas as a result of the

influence of inter-personal communication within the ecosystem via increasing the probability of their "infection" with an innovative idea. Here, t is the time scale of perception and implementation of open innovation as a result of inter-personal communication. Thus, Equation (3) takes the form:

$$\frac{df}{dt} = qfn(1-f) \text{ or } \frac{df(t)}{dt} = qf(t)n(t)(1-f(t)) \quad (5)$$

whose solution is

$$f = \frac{1}{1+\frac{1-f_0}{f_0}e^{-q\int_0^t n(t)dt}} \quad (6)$$

The graph of this function has a more pronounced bend to reflect the higher rate of innovation propagation.

Thus, the implementation of the proposed model for the dissemination of open innovation to be mediated by a management company will not only reduce the time required to search for innovative ideas but also increase the efficiency of their implementation. The practical introduction of the proposed model will ensure the acceleration of the pace of innovative development in domestic regions due to faster diffusion of open innovations. In fact, the proposed model differs from the current practice of implementing open innovations by domestic regions. On the one hand, this approach is more flexible, adaptive and accounts for mutually beneficial cooperation in contrast to the cluster model prevailing at the regional level. Such cooperation promotes forming the interaction via considering the exact interests of the actors, who are the most motivated to reach the best results, and not the interests of the strictly regulated leadership of the state. On the other hand, the formation of an ecosystem in its conventional version, which many researchers often discuss, can take a rather long time. The presence of a management company, which catalyzes inter-connections in the system, would significantly accelerate the formation of such an ecosystem and ensure preserving its inherent advantages and benefits.

Based on the data obtained, we envision further research as a deeper study of issues related to the functioning of the proposed approach, its effects and its advancement of the socio-economic development of regions due to a more intensive diffusion of innovations, distribution of competencies and functionality of actors in the model, scaling the model to the macro-level. Therefore, it is necessary to propose in subsequent studies a mechanism (i) to adapt the model based on its dependence on the level of RRII and (ii) to propose and calculate parameters for achieving the maximum effect.

To conclude, we should note that currently there is an active innovative development effort, mostly in the central regions of Russia, which appears to be rather fragmentary and does not form an integral innovation system in the state. Such a cluster approach has certain limitations, being dependent on quite strict state regulation, which hinders effective innovative development. As a way to approach the issue, we propose a synergetic developing of both cluster and ecosystem models that could allow one to intensify the practical application of the concept of open innovation and to ensure the "seamless" flow of innovations at the regional level.

The proposed development of the open innovation model based on employing the advantages of cluster and ecosystem approaches will contribute to faster dissemination of innovations among all the actors in the system through the implementation of the regulator function, which will speed up the processes at the regional level. In turn, the intensification of regional innovative development will accelerate innovation's diffusion at the national level.

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