Approaches to evaluating innovations transfer: from macro to micro level

Yuri Preobrazhenskiy[1], *Anna* Firsova[1*], *Olga* Chelnokova[1], and *Alla* Vavilina[2]

[1]Saratov State University, 83, Astrakhanskaya str., 410012 Saratov, Russia
[2]Peoples Friendship University of Russia (RUDN University), 6, Miklukho-Maklaya Street, 117198 Moscow, Russia

Abstract. In the modern economy, innovation has become an important determinant of economic growth and sustainable development, so the need to evaluate the effectiveness of the innovation transfer is increasing. The aim of the work is to develop the approach to the evaluation of innovation transfer effectiveness at macro, meso and micro levels of national economies. The paper also reveals the differences in the processes of knowledge spillover and the innovation transfer within innovation systems of different levels; as well it assesses the innovation transfer processes based on the data from Russian regions. The authors make some judgments about the effectiveness of technology transfer and analyze the prerequisites for knowledge spillover across Russian regions.

1 Introduction

In today's economy, technology and innovation are becoming, along with labor and capital, important determinants of economic growth and sustainable development.

The technological and economic power of any nation, its competitiveness and international market share depend on how efficient is the mechanisms for the development, adoption and utilization of innovations. With the development of the digital economy, these processes have radically transformed. The approaches to the analysis of innovation processes have also changed. In particular, the ecosystem approach allowed for a more holistic assessment of the interaction of all participants in the innovation process. However, the application of this approach is still limited to specific established ecosystems, while there is a need to apply this approach within the entire regional innovation system. The process of digitalization itself allows us to achieve this.

In this text, we describe the processes of transfer of innovations at various hierarchical levels, noting the differences in such descriptions. We also show how the description of innovation processes should be in order to blur the boundaries between different levels.Innovative technologies, the transfer of which to the recipient underlies a transfer process, are an intensive factor in the economic growth of any country. An efficient transfer of innovations has a positive effect on economic performance and the outcomes of economic policies. These processes are associated with a comprehensive structural

* Corresponding author: a.firsova@rambler.ru

transformation of the economy, which is expressed both as a change in the balance between its sectors and the emergence of new ones, and as a shift in the sectoral structure of the economy towards the growth of high-tech industries. In this context the problem of analyzing and evaluating the effectiveness of innovation transfer has become of particular relevance.

According to the OECD, there is a critically low level of innovation transfer, less than 3% of new technological developments are transferred to production replication within up to 1 year, and the total volume of knowledge conversion does not exceed 10% [1].

It is also necessary to revise and constantly update the technology transfer models in connection with the institutional transformation of the global, national and regional innovation systems [2,] [3].

Under these conditions, the problem of analyzing and evaluating the effectiveness of the innovations transfer acquires a high priority in research in the field of innovation management and makes the scientific search for models of technology transfer management especially relevant.

In this paper we consider approaches to assessing the knowledge and innovation spillover at different levels of the innovation system and analyze the specific problems of innovation transfer. The basic aim of the paper is to develop the approach to the evaluation of innovation transfer effectiveness at macro, meso and micro levels of national economies. We also reveals the differences in the processes of knowledge spillover and the innovation transfer within innovation systems of different levels; as well it assesses the innovation transfer processes based on the data from Russian regions.

2 Theoretical analysis

The study of key determinants and areas of innovation system development is topical in all countries and numerous academic works have been devoted to it in recent years [4-7]. Nowadays researchers of national and regional innovation systems emphasize the importance of effective knowledge spillover and innovation transfer [8]. The academic literature widely considers potential mechanisms for the development of regional innovation activity [9-13].

The conventional concept is of E. Rogers's point of view, who defined the diffusion of innovation as the process in which an innovation is communicated through certain channels over time and space among the members of a socio-economic system [14]. In present-day concepts of innovative development, the phenomenon of innovation diffusion is central, as it is associated with the dissemination of product and process innovations through a system of information, economic, organizational and managerial links among all elements and subsystems of the national innovation system.

Innovations can be communicated in the course of the innovations transfer by intentional and, as a rule, paid, transfer, as well as through spillovers, i.e. free flow of knowledge and innovation. The phenomenon of spillover effects occurs when knowledge and information employed for a particular innovative product or project in its turn creates new opportunities for applying this knowledge to other areas of innovation [15].

An important aspect of the study of innovation transfer processes is identifying the mechanisms and their features in the knowledge and innovation dissemination in various region innovation systems.

Scholars distinguish the main forms of innovation transfer - these are internal (sharing technology among units within the same organization) and external one (disseminating technology from its developer to the consumer, which are not interconnected).

Among other things, we can talk about different levels of technology transfer – this is the micro level (technology transfer within one organization or between several organizations within one economy) and the macro level (international or state-to-state technology transfer).

At present, researchers generally accept that there exist several levels of regional innovation systems, "overlapping" each other. So, researchers highlight the global (international), national and regional innovation systems. In so doing, it is advisable to distinguish even lower, micro and intercompany level of interaction in the field of transfer and spillover of knowledge and innovation.

In recent years, the ecosystem approach has been actively applied, in the framework of which knowledge and innovation circulate within and between ecosystems of knowledge, innovation, and business. Innovation as the process of transforming an idea into a marketable product requires a lot of collective efforts of participants: companies, universities, research companies, venture capital funds and innovative infrastructure organizations. The innovation ecosystem offers a tool for creating conditions that increase the competitiveness of firms in national and regional economies and formalizes these efforts, providing a synergistic effect [16-19]. From an ecosystem approach perspective, social interaction of actors within an ecosystem and between different ecosystems is of great importance; therefore ecosystems are relatively local formations [14].

The ecosystem approach is a consequence of the transition to a digital economy. It allows to abandon the disproportionate analysis of the transfer of innovations at three levels and move on to considering territorial innovation systems as a set of ecosystems of different levels (fig. 1).

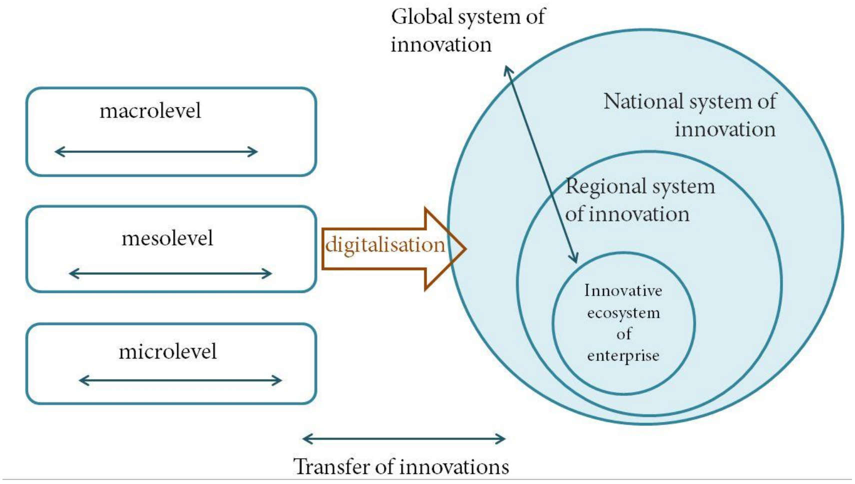

Fig. 1. Relationship between global, national, regional innovation systems.

Discussing the nature of regional innovation systems boundaries, S. Edqvist notes that it can be a matter of geography (when analyzing spatial boundaries) or sectors of the economy [20].

Eliminating boundaries and embedding a low-level innovation system into a higher-level system is essential for the diffusion and transfer of knowledge and innovation.

In our opinion, it is more scientifically significant to analyse the effectiveness of innovations diffusion in innovation systems of different levels based on both a systemic and a spatial approach. The systematic approach is focused on revealing connections between various elements and actors of regional activity and on identifying the configuration that will allow a region or an innovative firm to develop in the most efficient way [21]. Thanks to the spatial approach, the study takes on an additional dimension, and the processes of innovation can be recorded on the map (including using geographic information systems).

In the course of this research we reveal the differences in the processes of knowledge spillover and the transfer of innovations within innovation systems of different levels; as well we identify the approaches and indicators for evaluating the effectiveness of the innovation transfer and assess the processes of innovation transfer based on the data from Russian regions.

3 Results: empirical analysis of transfer on different levels of innovation systems

3.1 Macrolevel

At the macro level, the main object of analysis is the national innovation system. It acts both as an independent formation that generates and utilizes knowledge and innovation, and as a member of the global innovation system, whose development and links with other national innovation systems determine its and their development. Thus, at the macrolevel, one can distinguish between internal and external interactions of the country.

For the technology transfer development evaluation between countries, it is possible to apply a system of indicators, which is based on the available international methodologies and includes:

1) R&D costs share in GDP;
2) export of high-tech products;
3) number of the registered patent applications;
4) position in the Global Innovation Index.

The structure of R&D costs in Russia is worth out attention, as it is generally quite typical compared to developed countries (see Table 1).

Table 1. R&D cost structure, 2017

Country	Basic research	Applied research	Development
Japan	0.14	0.20	0.67
South Korea	0.14	0.22	0.64
USA	0.17	0.20	0.63
China	0.06	0.11	0.84
Russia	0.15	0,18	0.67

Sources: OECD [22], Rosstat [23]

The analysis of the technology transfer development at the macrolevel is carried out based on the figures of international trade in technologies with foreign countries.

For example, for Russia, within the country, as the study by Zharova E.N. and Gribovsky A.V. [4] demonstrates, the analysis of the dynamics and efficiency of the innovation transfer can be carried out on the basis of the following indicators:
- sources of acquiring advanced production technologies;
- the quantity of valid patents in the country;
- the number of concluded agreements for the sale of patent licenses and the alienation of patent rights;

- distribution of internal agreements for the sale and purchase of licenses by the categories of economic entities.

In addition, a number of studies for evaluating the dynamics and effectiveness of technology transfer at the regional level propose to use, for example, R&D costs by regions, the share of each region in the export of high-tech products, the number of highly qualified personnel, the rating of innovative development, the number of units of innovative infrastructure, such as industrial parks and technology towns in the region.

3.2 Mesolevel

Regional innovation systems are formed and function at the mesolevel. The search for a 'new' model of regional development makes it important to use a systematic and spatial approach to the study of innovation transfer.

As we noted earlier, it seems highly questionable to identify regional innovation systems with the mesoeconomic system of the region only because of its being within the administrative boundaries [25]. C. Edquist believes that geographical boundaries are more applicable to national innovation systems than to regional innovation ones [20]. In reality, many regions are unable to form full-fledged innovation systems.

According to B. Asheim and L. Coenen regional innovation system consists of ‘interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems’ that may stretch across several sectors in the regional economy [26, p. 1174]. Knowledge acts as the central link uniting the entire regional innovation system, on the efficiency of dissemination of which the functioning and developing of the entire system depends.

With regard to the mesoeconomic system, a set of indicators for evaluating technology transfer is presented by Maksimov Yu. M., Mityakov S. N. and Mityakova O. I. [27]. Analyzing the technology transfer as a process that occurs either through the direct implementation of the scientific findings acquired by research institutes and universities at industrial enterprises, or through promoting innovations to industrial enterprises with innovative structures, the researchers focus on its second development option. At the same time, they characterize the stages of the transfer (the stage of a scientific and technical project; the stage of producing prototypes or small series of innovative products; the stage of mass production) and highlight such indicators for assessing the transfer as costs, profit and revenue, emphasizing the need to analyze these indicators for each stage of the transfer.

At the mesolevel in Russian regions, the innovation dissemination can be illustrated by the efficiency of utilizing the results of intellectual activity. To do this, we calculated the corresponding:

$$Ce = \frac{Us}{Is}, \qquad (1)$$

where: Ce is an coefficient of efficiency of utilization of the results of innovation activity in the region; Us is a number of utilization of the results of intellectual property; Is is a number of issuance of patents as a results of intellectual activity.

The calculations of the transfer efficiency coefficient for 70 out of 85 Russian regions in which the results of innovative activities were created and utilized are presented in Table 2. In other regions, there were no indicators of either developing or utilizing the results of innovation activity.

Different colors in the table highlight the groups of regions according to the Ce rates - the efficiency coefficient of utilizing the results of intellectual activity. The mean value of the efficiency coefficient for Russian regions is 2.16.

The calculations show that a number of Russian regions use many times more results of intellectual activity than they produce themselves. Note that the first eight regions in the table are industrially developed; the manufacturing industry occupies a high share in the structure of their economy. This is typical for all regions with a Ce coefficient higher than 4.

Table 2. Ratio of utilized results of intellectual activity to registered results of intellectual activity by region, 2017, times.

Ce coefficient	Regions
more than 10	3 regions: Tula region, Republic of Khakassia, Perm region
4 - 10	14 regions: Kurgan region, Republic of Tatarstan, Udmurt Republic, Nizhny Novgorod region, Chuvash Republic, Ryazan region, Pskov oblast, Republic of Komi, Zabaikalsky Krai, Kirov region, Samara region, Vladimir region,Yaroslavl region, Sverdlovsk region
2.16 - 4	17 regions: Tver region, Novgorod region, Irkutsk region, Penza region, Saratov region, Chelyabinsk region, Stavropol region, Kaluga region, Novosibirsk region, Omsk region, Ulyanovsk region, Moscow oblast, Khabarovsk territory, Lipetsk region, Leningrad region, Tyumen region, Kursk region
less than 2.16	36 regions: Kostroma region, Krasnoyarsk region, Republic of Altai, Republic of Bashkortostan, Republic of Sakha (Yakutia), Vologda region, Saint-Petersburg, Republic of Karelia, Moscow City, Smolensk region, Amur region, Voronezh region, Tambov region, Sakhalin region, Volgograd region, Rostov region, Primorsky Krai, Ivanovo region, Altai territory, Republic of Mordovia, Belgorod region, Murmansk region, Tomsk region, Arkhangelsk region, Kaliningrad region, Kemerovo region, Republic of North Ossetia – Alania, Orenburg region, Krasnodar region, Magadan region, Astrakhan region, Orel region, Bryansk region, Republic of Dagestan, Republic of Mari El, Republic of Buryatia

It should be noted, the specifics of the Russian innovation space is that the development of regions of Russia is characterized by high unevenness in various aspects, particularly in the innovation activity efficiency [28].

Fig. 2 makes it possible to see that the most active regions in intellectual activity are Moscow City, Saint-Petersburg, and Moscow oblast. They demonstrate relatively low performance in its utilizing. The knowledge created in these regions flows to other regions that do not have a powerful scientific capacity. Note that Moscow City is not presented in fig. 2 since 5602 patents were granted there.

Nevertheless, in the regional context, we can note significant differences in the structure of R&D costs and, on this basis, we can distinguish four groups of regions (table 2).

A similar algorithm can be applied to the structure of R&D costs in the regional context. To do this, we calculated the shares of expenditures on fundamental and applied research and development, and then the regions were grouped by the dominant share (table 3). As a result, we identified three groups of regions:

- with prevalent costs of fundamental research (Smolensk region, Republic of Karelia, Murmansk region, mainly southern republics, etc.);
- with the prevalence of applied research (Krasnodar region, Astrakhan region, Stavropol region, Tyumen region, Khabarovsk territory);
- with the prevalence of design costs.

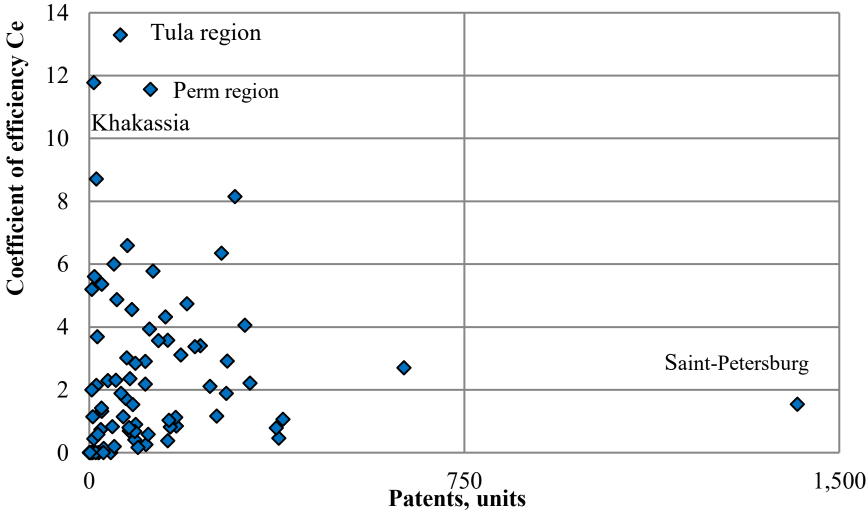

Fig. 2. Distribution of regions by the result of intellectual activity, 2017.

There is also a group of regions with a proportionate R&D cost structure.

The fundamental research carried out in the regions from the first group will obviously be included in the innovation process in some way.

Consequently, it is from them that the knowledge spillover will most actively take place in the regions where there is a great focus on applied research and development. It is clear that many Russian regions of this group (primarily the southern republics) provide a relatively small increase in fundamental knowledge. This fact should be taken into account. Regions with expenditures of fundamental research of more than 1 billion rubles are mainly in the Asian part of Russia (Novosibirsk region, Primorsky Krai, Irkutsk region, Republic of Sakha (Yakutia), they are listed in descending order).

It seems quite justified to assume that fundamental and applied research should be in demand at the next stage of the innovation cycle. The knowledge created at this stage will spill over into other regions with a predominance of fundamental and applied research and regions where R&D costs dominate in the structure of R&D. As applied to the graph (Fig. 3), we can expect a knowledge spillover from the group of regions located below (to the right) of the red line to the regions above (to the left) of this line. Let us note that Moscow City, Saint-Petersburg, Moscow oblast, as well as regions from which there are no publicly available data, are not indicated in fig. 3.

Of particular note is the regions where R&D costs generally exceed the volume of innovative products manufactured. This group is dominated by the southern republics and the republics in the north of the European Russia. However, R&D costs are modest there. Regions with a high level of R&D costs are of particular interest. First of all, this is Moscow, where R&D costs amounted to 335 billion rubles. (one and a half times more than innovative products manufactured). The high proportion of the capital city's R&D expenditures (about one third of the national value) does not allow it to be directly compared with other constituent entities of the Russian Federation. Primorsky territory with R&D expenditures of 6 billion rubles and the Komi Republic (2 billion) are geographically distant from Moscow and by the value of this indicator. In other regions depicted on the graph, R&D costs are less than 1 billion rubles.

https://doi.org/10.1051/e3sconf/202337104038

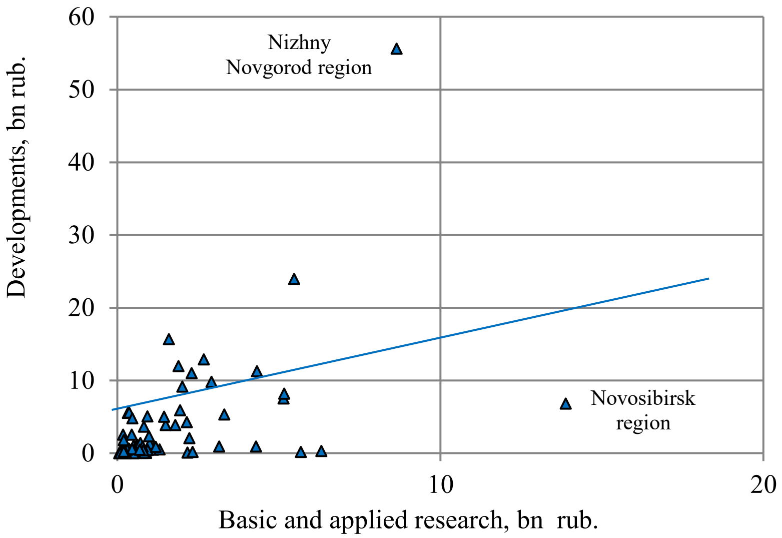

Fig. 3. Balance between fundamental and applied research and development costs by regions of Russia.

The analysis of Russian regions demonstrates that the overall low density of innovation space impedes the dissemination of innovation in the country. This results in the low potential of spillover effects in the Russian innovation space. The ongoing processes of polarization in the Russian economic and innovation space lead to shaping their breaking up, insular character. So, this can be quite clearly seen in the territorial analysis of the output of innovative products (fig. 4).

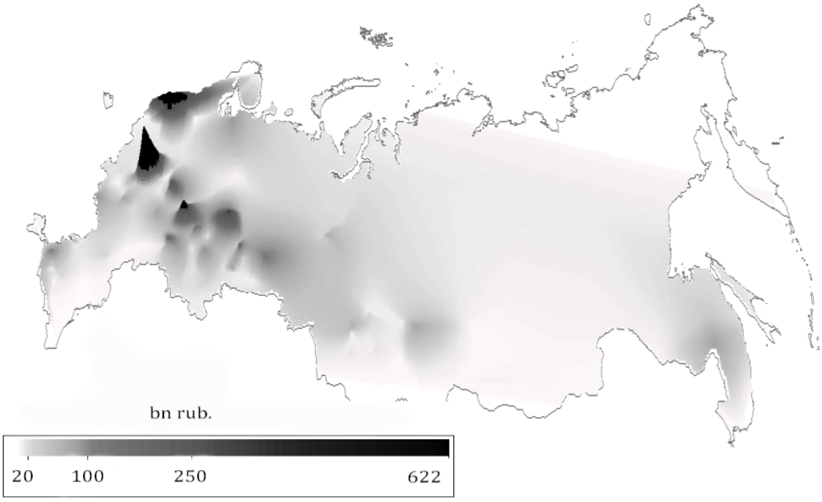

Fig. 4. Volume of innovative goods, bn rub., 2018 (3D model).

3.3 Microlevel

Summarizing the attempts made to date to work out indicators and tools for evaluating the transfer of innovative technologies at the microlevel, we note the diversity of the transfer process itself and its object, which can be patents of inventions, certificates of industrial designs and know-how, experience in the form of technical economic feasibility studies, technological knowledge, information, tangible assets, technological equipment, innovative products etc.

At the microlevel, the transfer of knowledge and technology occurs within one organization or between several organizations within an agglomeration. The fundamental difference between the dissemination of knowledge at the microlevel is the direct interaction of actors interested in its transfer. In the course of the latter, uncodified knowledge is exchanged in the course of communication or observation of a specialist's operations. Accordingly, the enhanced interaction can be stimulated, among other things, by creating proper conditions for it, including holding conferences, fairs, open days, etc.

However, it is difficult to assess quantitatively the result of the actors' interaction. At the same time, the influence of direct contact on the further explication of knowledge can be illustrated by the citations in articles, as B. Milard, demonstrating that in chemical science most of the citations fall on scientists familiar to the author [29].

You can more accurately assess the transfer of already shaped technologies. To do this, at the microlevel, for assessing the effectiveness of technology transfer within the existing dynamic (discounted) method of analysis, it is possible to use such an indicator as net present income. But it should be noted that in this case technology transfer is considered exclusively as an investment project, i.e. as an economic phenomenon, rather than an economic process.

We believe that when considering the process of technology transfer at the level of an individual economic entity (enterprise or firm), a number of the following indicators could be used as figures for assessing its dynamics:

- the number of innovations purchased by the enterprise,
- the number of projects implemented jointly with other enterprises, research institutes or design organizations,
- the number of fairs and exhibitions of new products in which the company took part,
- the number of introduced innovations developed by the enterprise itself,
- the number of innovations introduced at the enterprise over the reporting year,
- the amount of technological innovations costs, etc.

At the microlevel, the development of an agent-oriented approach, network structures, intensification of interaction among science, business and regulatory bodies is especially promising [30, 31]. It is precisely the knowledge, business, and production ecosystems at different stages of formation that have a local binding that are (or will become) the cores around which a full-fledged results of intellectual activity will be formed.

4 Discussion

In fact, there has been a paradigm shift in the past decade. The attention of researchers shifted from studying the number and impacts of patents and licensing to understanding interinstitutional variations in the range and efficiency of technology transfer activities [32]. From a quantitative assessment of the intensity of the transfer, researchers are moving on to identifying the factors that affect it, that is, they are moving on to a quality assessment of the conditions of the diffusion innovation.

 https://doi.org/10.1051/e3sconf/202337104038

The need to consider together horizontal and vertical connections between participants in the innovation process, in our opinion, led to the emergence and development of system concepts: National Learning Systems [33], National Entrepreneurial Systems [34], National Business System [35] and Innovation Ecosystem [36]. However, despite their heuristic value, a need arose to develop a methodology for network interaction between participants in the innovation process [37-38]. Probably, the combination of these system and network approaches will allow the most complete description of the process of transfer of innovations.

Our cursory research focused on the specifics of the transfer of innovations at different levels; a number of problems remained outside it. In particular, one of them concerns the peculiarities of interaction between generators and recipients of knowledge. For example, Ungureanu et al. analyze the transfer process "... from two perspectives, namely: from the perspective of companies that apply the innovations and from the perspective of universities as suppliers of technologies and knowledge" [39]. No less important is the analysis of intersectoral interaction. The sectoral perspective offers important insights into the role of technological factors for those in charge of industrial policy [40]. The main idea based on the concept of a sectoral system of innovation [41].

Another issue is the extent to which the efficiency of the transfer of innovations at one level affects another. For example, to what extent does innovation interaction at the local level between firms affect interregional interaction or even the transfer of innovation between countries? The available works are mainly devoted to one of the analyzed levels of innovation transfer: national, regional, or local. This makes it possible to compare knowledge spillover processes in two different regions or between two or more countries, or, for example, within local clusters of different industries, that is, there is a possibility of horizontal comparison. But understanding the vertical connections between different levels of transfer is still far from clear.

5 Conclusion

Thus, the research allows us to draw several conclusions.

First, the diversity of existing indicators used for assessing the technology transfer process at various levels of its development once again indicates the complexity and ambiguity of the problem of analyzing and evaluating the transfer of innovative technologies.

Second, at the level of the national innovation system, there is the lack of efficiency of the functioning technology transfer system. At the same time, despite the recognized need for developing and forming a unified international methodology for assessing the dynamics and effectiveness of the technology transfer process, unfortunately, it has not yet been created.

Third, at the level of regional innovation systems, there are regions that produce knowledge and actively utilize it, which indicates a significant knowledge spillover between regions. We reached the same conclusion in a different way in the work [42].

Fourth, the overall low density of innovation space impedes the diffusion of innovations in the country. This results in the low potential of spillover effects in the Russian innovation space.

Fifth, at the microlevel, we highlight the importance of interaction between the actors of scientific and innovation activities and the creation of scientific, innovation and business ecosystems, which will contribute to the intensification of knowledge and innovation transfer.

Such an analysis is in demand in any country with heterogeneous geographic and economic space. The modern economy requires a model of innovation diffusion, which should combine technology transfer and knowledge spillover based on multilateral networking.

Therefore, further research will be associated with the development of a system of indicators that allow for more accurate assessing the effectiveness of the knowledge and innovation dissemination at various regional levels, as well as with the development of mechanisms for institutional interaction of actors of the national innovation system.

6 Acknowledgements

The research was supported by Russian Science Foundation (project No. 19-18- 00199).

References

1. OECD Statistics on International Trade in Services (2018). Iss. 1: Detailed Tables by Service Category, OECD Publishing
2. A. Andrenelli, J. Gourdon, E. Moise, OECD Trade Policy Papers **222** (2019)
3. V.G. Stepchenko, N.I. Glushak, O.V. Glushak, V.K. Khlebnikov, Bulletin of the Altai Academy of Economics and Law **2(8),** 191-198 (2019). doi:10.17513/vaael.687
4. T. Hagerstrand, Innovation Diffusion as a Spatial Process (The University of Chicago Press, 1967)
5. K. Blind, H. Grupp, Res. Policy **28(2),** 451-468 (1999). doi:/10.1016/s0048-7333(99)00007-4
6. B.-A. Lundvall, Industry and Innovation **14(1),** 95–119 (2007). doi:10.1080/13662710601130863
7. T. Brenner, T. Broekel, Ann. Reg. Sci. **47(1),** 169–194 (2011). doi:10.1007/s00168-009-0364-x
8. R. Camagni, R. Capello, Growth and change **44(2),** 355-389 (2013). doi:10.1111/grow.12012
9. P. McCann, R. Ortega-Argilés, Cambridge J. Regions Econ. Soc**. 6(2),** 187-216 (2013). doi:10.1093/cjres/rst007
10. M. Grillitsch, M. Nilsson, Ann. Reg. Sci. **54(1),** 299-321 (2015). doi:10.1007/s00168-014-0655-8
11. D.B. Audretsch, M. Belitski, Eur. Econ. Rev. **123,** 103391 (2020). doi:10.1016/j.euroecorev.2020.103391
12. M. Grillitsch, M. Nilsson, Ann. Reg. Sci. **54(1),** 299-321 (2015). doi:10.1007/s00168-014-0655-8
13. K. Flanagan, E. Uyarra, Environment and Planning C: Government and Policy **28,** 681-695 (2010). doi:10.1068/c0961
14. E.M. Rogers, Diffusion of innovations (5th edn. Free Press, 2003)
15. Y.V. Preobrazhenskiy, A.A. Firsova, Indonesian Journal of Geography **52(3),** 368–373 (2021). doi.org/10.22146/ijg.53445
16. G. Andersson, Systemic Practice and Action Res. **26(1),** 99-110 (2013). doi:10.1007/s11213-012-9265-5
17. C.W. Wessner, Innovation policies for the 21st century. Report of a symposium (The National Academies Press, 2007)

18. S. Durst, P. Poutanen, Success factors of innovation ecosystems - Initial insights from literature review (CO-CREATE, 27-38, 2013)
19. R. Adner, Match your innovation strategy to your innovation ecosystem. (Harvard Business Review, 2006)
20. C. Edquist, Systems of innovation: perspectives and challenges, The Oxford Handbook of Innovation (Oxford University Press, 2005)
21. B. Asheim, M. Gertler, The geography of innovation: regional innovation systems, The Oxford Handbook of Innovation (Oxford University Press, 291–317, 2005)
22. OECD. (2020). Main Science and Technology Indicators, OECD Publishing, doi:10.1787/e3c3bda6-en
23. The Russian Federal Service of State Statistics, Retrieved from: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/statistics/science_and_innovations/science/# [accessed: 28 September 2020]
24. E.N. Zharova, A.V. Gribovsky, Bulletin of the V. N. Tatishchev Volga state University **1(4)**, 196-203 (2017)
25. Y.V. Preobrazhenskiy, A.A. Firsova, D. A. Muzhenskiy, WSEAS Transactions on Environment and Development **16**, 530-538 (2020). doi:10.37394/232015.2020.16.54
26. B. Asheim, L. Coenen, Research Policy **34**, 1173–1190 (2005)
27. Yu.M. Maksimov, S.N. Mityakov, O.I. Mityakova, Innovations **7,** 84-86 (2006)
28. A.A. Firsova, G.Yu. Chernyshova, R.R. Tugusheva, Mathematics **10, 2,** 173 (2022) doi:10.3390/math10020173
29. B. Milard, J. of the Association for Inf. Sci. and Technology **65(12),** 2459-2468 (2014)
30. A.A. Firsova, R.R. Tugusheva, E.L. Makarova, J. of Open Innov.: Technology, Market, and Complexity **6(2),** 32 (2020). doi:10.3390/joitmc6020032
31. O.Yu. Chelnokova, L.E. Gritsak, Izv. Saratov Univ. (N.S.), Ser. Economics. Management. Law **13(1),** 8-14 (2013)
32. J. Bercowitz, M. Feldman, I. Feller, R. Burton, J. of Technology Transfer **26,** 21-35 (2001)
33. E.B. Viotti, Technological. Forecasting and Social Change **69,** 653–80 (2002)
34. Z.J. Ács, E. Autio, L. Szerb, Research Policy **43,** 476–94 (2014)
35. R. Whitley, Organization Studies **15(2),** 153–82 (1994)
36. J.F. Moore, Business Review **71,** 75–83 (1993)
37. R. Huggins, P.A. Thompson, J. of Economic Geography **14(3),** 511-545 (2014). doi:10.1093/jeg/lbt012
38. A.L.J. Ter Wal, R. Boschma, The Annals of Regional Sci. **43(3),** 739–756 (2009)
39. M. Ungureanu, N. Pop, N. Ungureanu, Procedia Eng. **149**, 495-500 (2016). doi:10.1016/j.proeng.2016.06.697.
40. C. Chaminade, B.-Å. Lundvall, Sh. Haneef, Advanced Introduction to National Innovation Systems (Edward Elgar Publishing, 2018)
41. S. Breschi, F. Malerba, *Sectoral innovation systems: Technological regimes, Schumpeterian dynamics, and spatial boundaries.* In C. Edquist (Ed.) (Systems of innovation: Technologies, institutions and organizations, Pinter, 1997)
42. Yu.V. Preobrazhenskij, Vestnik of Samara State University of Econ. **10,** 14-23 (2020). doi:10.46554/1993-0453-2020-10-192-14-23