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The Influence of Innovation on Social and Economic Development of the Russian Regions

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Abstract:

The article provides estimates of innovation parameters' influence on social and economic development of regions measured as per capita gross regional product.

The empirical part of the research comprises the regression model that demonstrates interrelations in a region-wide breakdown, considering the differentiation of innovation development level of regions grouped into homogenous clusters.

The results provide evidence of two forces. One of these stands for the traditional academic and industrial science attributed with plan-fact indicators. The other, in its idea and contents, is fully matching with the R&D market concept since it exists and functions in a competitive environment, strives to self-financing and commercialization.

Therefore, performance indicators and growth rates of this segment are far ahead the ones of the traditional science.

Keywords: *Region, territory, social and economic development, regional development, innovation activity, national innovation system, the new economy*

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1. Introduction

Innovation driven development is among the priorities of public policy of all the leading countries. It presumes continuous introduction and implementation of promising R&D outcomes and breakthrough technological, organizational, manufacturing innovations and best practices to create and commercialize innovation-bearing products. The key idea of innovation driven development is to design an innovation economy that implements economic growth model transformation through the shift from extensive development mode to the intensive mode. Attributes of the latter include higher labor productivity entailed from new technology utilization.

Economically, a change to innovation driven mode of development is explained by several reasons: it increases return and efficiency of industrial output, provides maximum performance in social tasks resolving. Public governance of the drift towards innovation driven mode is regulated by the national and regional innovation policy development and implementation (Kitagawa, 2017; Frank *et al.*, 2016).

To facilitate scientific discoveries, major inventions and new technology adaptation regions need to evaluate the required and possible extent of incentives and support of innovators considering the existing intellectual and resource potential (funding system, human capital in R&D, etc.). Regional authorities arrange access to the resource base, performance of which is determined by the intensity of its use by innovation system's actors. The intensity of resource consumption is, in turn, determined by actors' ability to cooperate and communicate with each other.

2. Literature review and methodology background

2.1 Innovation activity conceptual framework

Technology is the knowledge applied to solve practical problems. Commercialization of any technologies created in the process of R&D supposes transition of technologies to the level of innovation. According to Schumpeter (1934), who introduced the concept of innovation in economic discourse, the following classification of new combinations of production methods is featured:

- ✓ introduction of a new product / service;
- ✓ introduction of a new method of production (new technology);
- ✓ contracting a new source of raw materials;
- ✓ entering a new market;
- ✓ deployment of new business processes.

Schumpeter's classification covers the main types of innovation on the supply side. The up-to-date list of innovations is not comprehensive (Avdeeva, 2018), since innovation can be introduced not only from the supply side, but also from the demand side as well (Metcalfe, 2001). Thus, innovation activity of an enterprise is the process of technology commercialization, the result of which is new economic goods, new modes of the existing goods' use, or a change of an enterprise's competitive environment. Together they comprise a concept of innovation driven development of a territory (Karpova *et al.*, 2019; Zedgenizova and Ignatyeva, 2017).

Since the development paradigm has changed, almost all territories seem to have a key attribute of the modern stage of development: innovation driven processes are implemented in all spheres of practice that evidence the drift from industrial economy to knowledge economy (Mas-Verdu *et al.*, 2010). The "new economy" concept is present in various methodological interpretations, yet most researchers and practitioners – see Mackinnon *et. al*. (2002), Sánchez-Carreira *et al.* (2018), Hansen and Winther (2011), etc. – are unanimous in opinion that fundamentals of its development lie within the national innovation system and its parameters transformation.

Systematization of research publications on the matters of innovation systems functioning and mechanisms of their development allows to define the national innovation system as a complex subsystem that provides generation, distribution and commercial adaptation of ideas, knowledge and technologies that are usually present in innovation products (Kolmakov *et al.*, 2015; Tyaglov *et al.*, 2017).

Our analysis of innovation activity contents proves that theoretical foundations of this issue are very debatable and do not have a uniform well-established methodological basis (Akopova and Przhedetskaya, 2016). In some cases, the concept of "innovation activity" is used to identify existing phenomena, and sometimes researchers use it to designate specific processes. Depending on the situations identified, there are two questions: first, how to distinguish a process within a given environment and which components to include in the process; second, how to describe a process regarding the existing set of requirements.

2.2 Methodology of modeling the regional development change in response to innovation activity inputs

In most cases, the assessment of regional innovation activity is based on rankings, which, yet being very explanatory in terms of presenting results, allow only a superficial estimate of a region's relative position compared to other regions showing the difference between them. They are poorly adapted for solving several research tasks that require presence of groups of regions like each other with enough and significant intergroup differences. In this regard, the classification of objects based on clustering was used as an analysis method for typology. More important is to note that clustering effects in their natural representation – aglomerations – have a positive impact on develpment in general terms, as wel las in details as innovation, etc., (Gordon and McCann, 2005).

Cluster analysis, being a method of multiple classification, allows to consider many parameters having a different nature, measurement scales and significance in terms of impact on the final indicators. At the same time, one cannot but agree that there is no optimal configuration of national innovation systems. We are much likely to consider the complementarity of individual systems, rather than their convergence to a single system. Each of these systems, according to Finogenova *et al*. (2017), has a different speed of reaction to technological transformations. This means that any typology is biased by the tasks set by a researcher.

The authors' algorithm to identify groups of Russian regions in terms of the level of development of innovation activity, as well to assess its impact on socio-economic development, is represented by the following procedures:

1. Preliminary procedures to design typology;
1.1. Data collection. The data published by the Russian Federal Statistics Service were employed.
1.2. Data conversion and scaling.
1.3. Data multicollinearity tests.
1.4. Elimination of pairwise-dependent indicators.
2. Clustering regions and analysis of outcomes: means variance and distribution, the degree of intergroup difference, intra-cluster relative indicators;
3. Testing the degree of regional socio-economic development indicators on the outcomes of innovation activities using multiple regression modeling.

All clustering algorithms are designed to estimate the distance between clusters or objects, which makes the problem of indicators scales relevant: different measurement scales and number of digits can make the analysis results difficult to interpret. In this regard, the initial data were calibrated to bring them to the uniform scale.

Although multicollinearity tests of variables are not necessary to run cluster analysis, still there is a need for it, because, first, it is necessary to exclude "duplicate" and interdependent factors, second, to reduce the number of parameters in scope. Estimates of pair correlation show that the most indicators are closely related to each other, demonstrating values at 0.9 (by absolute) and above.

Considering the differences in the region's level of socio-economic development, any conclusion about their innovation activity, made on retrospective data, can hardly be unambiguous. Thus, we find it necessary to adjust our research approach to refer the dynamic characteristics of innovation development – to use growth rates and indexes instead of raw data.

This approach has several fundamental advantages. First, it makes it possible to estimate the changes happening under the influence of the global financial crisis aftermath, when the federal government and regions were forced to suspend or substantially reduce funding for research and development. This circumstance allows to take a reverse look at innovations dynamics using the bottom-up approach: data on innovations funded by non-public sources can be more valuable in terms of deriving nontrivial research outcomes. Secondly, this approach standardizes the data under study, which allows us to unambiguously interpret the results obtained. The following assumptions were made:

1. The approach "equalizes" the previous achievements of the regions in terms of the development of innovations, assessing only their activity compared with the previous period. So, from the point of view of analysis results, for example, a constant number of advanced technologies used is considered as a zero-growth rate, regardless of their number (Safina *et al.*, 2016; Safiullin *et al.*, 2016).

2. For computational purposes, a change in the value of the indicator from zero to a non-zero value is estimated as 100% growth rate.

Thus, reiteration of correlation indicates the presence of the following significant relationships:

- ✓ the increase of quantity of organizations engaged in research entails an increase in the number of research personnel, as well as the costs of applied and basic research;
- ✓ the increase of R&D expenditure entails an increase of the number of patents granted for inventions;
- ✓ the increase in the number of advanced technologies employed entails an increase in the share of innovative products and training costs.

Consequently, from further consideration were excluded such indicators as number of research organizations, number of patents granted for inventions, share of innovative products and cost of training to use innovation. The set of remaining indicators was subjected to cluster analysis in the original values, which were logarithm-scaled.

3. Results and discussion

Cluster analysis was used to verify the following hypothesis: there are 5 non-single clusters, significantly different from each other. The hypothesis was proved positive. The five clusters were derived; their members listed in Table 1.

Table 1: *Cluster distribution of the Russian regions*

Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**
Under-implemented innovation potential	Mainstream of innovation	New to innovation	Outsiders	Leaders
Total count: 30	Total count: 23	Total count: 17	Total count: 8	Total count: 4

Oblast: Belgorod, Bryansk, Ivanovo, Kursk, Oryol, Ryazan, Smolensk, Tambov, Tverskaya, Tula, Arkhangelsk, Vologodskaya, Kaliningrad, Murmansk, Novgorod, Kirov, Orenburg, Penza, Kurgan, Kemerovo Rep. Komi, Rep. Dagestan, Rep. Mordovia, Udmurt Rep., Chuvash Rep., Rep. Sakha (Yakutia), Ugra autonomous okrug, Stavropol krai, Altai Krai, Khabarovsk krai	Oblast: Vladimir, Kaluga, Yaroslavl, Leningrad, Volgograd, Rostov, Samara, Saratov, Ulyanovsk, Sverdlovsk, Tyumen, Chelyabinsk, Irkutsk, Novosibirsk, Omsk, Tomsk, Voronezh Krasnodar krai, Perm krai, Krasnoyarsk krai, Primorsky krai, Rep. Bashkortostan, Rep. Tatarstan	Oblast: Kostroma, Lipetsk, Pskov, Astrakhan, Amur, Magadan, Sakhalin, Rep. Karelia, Kabardino-Balkaria Rep., Karachay-Cherkess Rep., Rep. North Ossetia – Alania, Rep. Mari El, Rep. Buryatia, Rep. Khakassia Zabaikalsky krai, Kamchatka krai, Yamal-Nenets autonomous okrug	Rep. Adygea, Rep. Ingushetia, Rep. Kalmykia, Chechen Rep., Rep. Altai, Rep. Tyva, Evreiskaya autonomous oblast, Chukchi autonomous okrug	Moscow oblast, Moscow city, St. Petersburg, Nizhny Novgorod oblast

The least representative Cluster 5 includes only 4 regions of the Russian Federation: Moscow, St. Petersburg, Moscow oblast and Nizhny Novgorod oblast. In this cluster, the highest average values of indicators are observed, 10-plus times exceeding the worst Cluster 4 (with the lowest values). The difference between Cluster 5 and Cluster 2, the next best, is also quite large and significantly varies in terms of the "Number of used advanced technologies" and "Current R&D expenditure".

The clustering of regions in terms of innovation activity yielded ambiguous conclusions. The dilemma is that regions that are statistically recognized as outliers increase the extent of their difference from other regions every year. On the other hand, the situation is quite natural, considering the national priorities. In this regard, it would be correct to say that the research outcomes prove the existence in Russia of the so-called "controlled generation of innovations" where the main contributor is the government. Thus, we witness the change of the role played by the so-called supporting regions (regions with developed academic science – Novosibirsk. Krasnoyarsk, Tomsk, science cities) where the emergence of innovations occurs spontaneously as a product of their everyday operations driven by initiatives from innovators (scientists, inventors, industry rationalizers).

Cluster 4 containing 8 regions is rather interesting because it brings together territories with the lowest absolute values of innovation development indicators.

These are regions of small population, characterized by a relatively low level of socio-economic development. However, when considering the relative indicators, radically opposite conclusions are suggested. Thus, the innovation performance in relative terms – ratios of labor and resources spent to the number of advanced technologies created – appears to be higher than in the most regions. In other words, researchers in the outsider regions are much more efficient in terms of cost-to-output ratio.

Cluster means analysis allows to conclude that different types of regions are characterized by different types of innovation processes. Thus, in most regions, the well-established model remains, the result of the operation of which – an innovation product – is formed predominantly spontaneously. The effectiveness in this case is a function of the time spent, including the time to raise funding considering the existing budget constraints and regulations of per capita funding. In addition, the impact of crisis on innovation activity in regions of this type is most significant: if innovation activity is largely dependent on government sources of financing and flows inertially, without targets, indicated by the real sector, as well as without support from the real economy¸ the decline in innovation is the most significant.

The next stage of the research derived a model of regions' socio-economic development (GRP per capita) dependence on the level of innovation activity development. The model was based on all the Russian regions' data. Alternatively, specific regional models could not be estimated within clusters due to the lack of reliable data for prolonged series that is crucial for obtaining statistically significant results with a proper number of observations given available number of independent variables. For example, cluster 5 included four regions, which makes a model with 8 factors technically impossible.

The constructed multiple linear regression model is characterized by a relatively low determination coefficient (0.49), which indicates its insufficient statistical significance:

$$GRP_{PC} = \exp(-0.511X_1+0.013X_2+0.286X_3+0.155X_4-0.163X_5+ \\ +0.112X_6-0.002X_7+0.154X_8+5.881) \quad (1)$$

Nevertheless, the simulation results deserve consideration, because they provide the basis for meaningful conclusions. First, relatively high value of the intercept must be mentioned. It means that across the regions in scope no more than 3% of GRP variance is explained by fluctuations of innovation activity. In other words, per capita GRP in short-term and mid-term perspective shows almost no dependency on innovation development. Other regression coefficients also indicate the presence of curious phenomena. E.g., the "number of people employed in R&D" among the factors in scope is the most significant one to influence the GRP and its influence is negative: along with the growth of research personnel in regions we face a decrease of per capita GRP in the respective territories. The reverse dependence was studied by Doussard *et al*. (2017) to uncover that the US jobs market was positively reacting towards technology spillovers resulting from higher inputs of resources in R&D.

Rational interpretation might be the following: outsider regions strive to increase their innovation potential forming a certain reserve for the future, expecting a long-term effect. On the contrary, more prosperous regions in terms of per capita GRP do not feel the need for an additional influx of research personnel, remaining within the current structure of socio-economic system of a region. However, regions with greater extent of economic development have greater opportunities for financing R&D, as evidenced by regression coefficients estimates: as per capita GRP increases, there is an increase in the corresponding expenditure. Similar conclusions can be made regarding the of technological innovation expenditure.

4. Conclusion

We face a new type of regions being formed, having new management mechanisms and behavior models, with a high degree of state involvement in the process of creating an innovative environment through financing, support and infrastructure development.

The current situation in the R&D sector, as indicated by the analysis results, indicates the presence of two, so far unequal, “forces”. The first one is represented by traditional academic and industrial science attributed with plan-fact indicators of “activity implementation”. This segment’s performance varies in line with dynamics of R&D staff, number of dissertations presented and amount money, primarily – from public sources, spent on R&D. Another “force” by its nature and contents fully corresponds to the category “R&D market” since it operates on a competitive basis, tends to self-financing. This is the so-called mainstream, which is the de facto dominant source of commercialized and implemented research outcomes, its growth rates and performance indicators, according to the Russian Statistics Agency, are far ahead of the indicators of “traditional” science.

The obtained models indicate that the process a national innovation system setup in regions cannot be considered complete. Several standalone components and subsystems can be distinguished, still missing synchronization of their activities. Existing institutions can solve individual, fragmented tasks, whereas fully-potential nationwide innovation system can be deployed given the integration of legal, organizational and financial effort at all levels of managerial hierarchy. This enhances the role of research on the factors of innovation development at the regional level. The need to develop the institutional framework of the innovation economy represented by business incubators, corporations and foundations, associations and science cities can be clearly seen.

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