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Production Function Based on Input–Output and Growth Rate Indicators as a Tool for Assessment of Innovation Climate in Russian Regions

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Abstract: Assessment of the innovation climate in Russian regions is a priority. Given the uneven socio-economic development of the federation subjects, it is essential to determine their readiness for the transition to an innovative course. However, due to the high degree of differentiation in the socio-economic development of Russian regions, when using methods based solely on tracking indicators, there is a decrease in the objectivity of the assessment. This is caused by a significant spread in the values of the indicators, which provokes the distortion of the final calculations. To avoid the subjectivization of calculations, it is appropriate to supplement them with the construction of functional dependencies. In this regard, the purpose of the study was to substantiate hypotheses about the possibility of using the production function to assess regions' innovation climate. The process of evaluating the innovative climate of meso-territories is implemented using the methods of statistical analysis: absolute and relative statistical values, indices, interquartile range, time series, and regression analysis. As a result of building production function models in volumetric and temporal records, arguments are formulated regarding its use to characterize innovative conditions. In the study, an additional character of the production function was established; it is possible to use it, but with several assumptions. The obstacles to innovative transformations in the Russian regions are formulated based on the calculations. The scientific contribution of the authors comes down to substantiating the expediency of combining heterogeneous methods of analysis in identifying innovative conditions in Russian regions; it is proposed to combine both a generally recognized tool for these purposes—indicative analysis and a less common one—a production function.

Keywords: innovation economy; innovation climate; differentiation of innovation in meso environments; assessment; production function

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1. Introduction

The economy of the Russian Federation has been in dire need of transformation over the past few years. The raw material model, previously successfully used, is currently losing its position. Relying exclusively on stimulating the extractive sector without a balanced development of the manufacturing industry is futile. Such a position leads not only to a future shortage of non-renewable resources but also to an increase in dependence on imports of final products to a catastrophic level. Given this, the innovative economy deserves special attention.

An economic model is chosen in a particular region in accordance with several factors associated with changes in customer behavior and preferences or limited resources. The correlation between the growing demand for private and public goods and the resource capacity can be fully researched as soon as new solutions are implemented. The focus on resource conservation puts the innovation economy in the spotlight to this extent. Successful implementation of the innovation economy stays feasible unless individual regional trends are considered (Sukhovey and Golova 2020). That is particularly relevant for countries characterized by numerous meso-territories with drastically different levels of social and economic development, determining their potential for innovation and the degree of the end user's interest for innovation. This connection is why the identification of innovation prospects within the national economy is grounded on the assessment of the innovation climate in smaller integral territories—members of a larger economic complex (Rudskaya and Rodionov 2018).

Thus, for Russia, the assessment of innovative conditions is of particular importance since significant disproportions between the subjects of the federation and between Russian manufacturers can become an obstacle to large-scale innovative transformations. In addition, it is worth remembering that the development and implementation of innovations require a sufficient amount of production factors. Their qualitative and quantitative deficit is a constraint on innovative reforms.

The existing approaches to defining an innovation climate as favorable or unfavorable are diverse. Some researchers track changes inside a group of indicators reflecting the availability of production factors (Sukhovey and Golova 2020; Dementiev 2019; Khachatryan 2020). Others focus on financial aspects (Abdikeev et al. 2018; Seidl da Fonseca 2018), or functional dependencies between a whole variety of indicators that characterize the innovation potential of a territory (Seidl da Fonseca 2017). Despite quite promising prospects of applying the production function as an assessment tool, this issue has not been adequately considered in research papers. Implementation of the production function in the assessment of the innovation climate introduces several advantages. Firstly, it defines the need for particular resources in a region. Secondly, putting the classical structure of the production function aside, it describes the dependence of the production scale on other factors (Buravlev 2012; Kantor and Spivak 2019). And finally, it reveals potential transformation paths for the region's economy. Moreover, several scientists have succeeded in justifying diverse applications of the production function in macroeconomic analysis. In some works, the production function is considered as a method for evaluating the results of economic activity of macro-, meso- and micro-subjects (Kolomak 2011; Mamonov and Pestova 2015), in others—as a way to predict the needs for labor and other resources (Pakhomova et al. 2018). This paper instead observes the role of the production function in the assessment of various macroeconomic phenomena from an unconventional angle via the identification of such production factors as "capital", "labor," and "technologies" on an overall indicator of social and economic development—Gross Regional Product (GRP). Calculated coefficient values in the production function models based on input–output and growth rate indicators allow prioritizing a particular economic resource for the territorial and economic complex. Paying due attention to the predominant impact of "capital", "labor", and "technologies" on the scale of production paves the way to developing new ideas on strengthening each of the given factors, which is an obligatory condition for a successful transition to the innovative "rails". As stated above, such an approach to the role of the production function has not been comprehensively covered in scientific works, making this paper particularly relevant and up-to-date.

Structurally, this study is divided into several interrelated stages, each of which aims to achieve the stated goal.

In the first stage (Sections 1 and 2), an analysis of the provisions of scientific publications related, both directly and indirectly, to the issue of assessing the innovative environment of meso-territories (in the context of considering macro-, meso- and micro-subjects) was carried out. This made it possible to conclude that the topic of applying the production function to determine the predisposition of territories to innovative transformations is insufficiently developed and to formulate a hypothesis to be tested during the remaining stages of the study. In addition, the terminological basis of the study has been clarified.

At the second stage (Sections 3 and 4), the innovative conditions that have developed in the Russian regions are assessed. For this, a number of indicators were calculated. At the same time, the selection of indicators took into account their ability to reveal the following parameters of the innovation environment: availability of economic resources, involvement of power and management structures in support of innovative initiatives, and general need for innovation. The results of the calculations turned out to be ambiguous (considering the case of Russia). It has been found that investment in "capital" does not affect returns to scale as much as investment in "labor". Given this, additional calculations were made, which confirmed the underestimation of the labor force typical for the subjects of the federation.

At the third stage (Sections 3 and 4) the models of the production function are built in volumetric and tempo records for each subject of the federation. The characteristics of quality parameters of production function models are presented. The calculated coefficients of the obtained production function models are described in detail.

At the fourth stage (Section 5), the results obtained using different research methods (relative statistical values, regression equations) were compared, which made it possible to establish the auxiliary nature of the production function. To increase the objectivity of assessing innovative conditions in the subjects of the federation, it is possible to use it, but with a number of assumptions. Additionally, an approach is formulated for using the classical production function model to assess the dynamics of open innovation.

At the fifth stage (Section 6), obstacles to innovative transformations in the Russian regions are formulated. Conclusions are presented that generally summarize the results of the study, which indicate the promise of combining heterogeneous analysis tools to increase the objectivity of assessing innovative conditions meso-territories. At the same time, the scientific contribution of the authors is detailed.

2. Literature Review

2.1. Economics of Innovation: Connection with the Environment

Macro- and microeconomic actors operate within a constantly changing internal and external environment. In the first case, changes are traced in the individual purpose of a particular agent, while in the second—transformations tend to happen in the outer economic agents. Over time, endogenous processes affect the exogenous ones and vice versa, thereby contributing to the overall dynamic development. Nonetheless, sooner or later limited economic resources start hindering the growth of innovations. To prevent this from happening, it is essential to stick to the economic model to preserve a region's resource potential (Kharlamov and Kharlamova 2019; Rodionov et al. 2020). The innovation economy may serve as a perfect option for his goal because it is centered on the practical transformation of knowledge, inventions, and innovations into a tool for developing multiple benefits and goods, still rationalizing the use of resources (Kharlamova et al. 2020). What is more, this model is considered to be successful because it aims to build interaction between all parties involved in the innovation process to ensure its completeness—from articulating an idea to the market launch (Peterková et al. 2022)—and pay due attention to their interests, and to stimulate innovation activity via various forms of cooperation to create conditions for the correct allocation of resources (Nikonova 2018). The innovation economy is a complex multipurpose model that values the issues of strengthening the foundations of a sustainable national economy (Sukhovey and Golova 2016), enhancing support for entrepreneurs, and ensuring a decent standard of living. The innovation economy "pyramid" is built to balance the need for goods sufficient to meet the variety of personal and public demands and the availability of resources used in production. To find this balance, the innovation economy implements breakthrough solutions, uses resource-friendly information and communication technologies, and launches innovative goods, thereby ensuring qualitative and quantitative economic growth (Park and Choi 2019). Economic development ranks first among all the goals, based on the inevitable changes in the institutional environment of the national economy, which are necessary to keep the macro- and microeconomic actors functioning. Alongside the structural reforms, a new paradigm of the interaction between the actors is developed to protect all mutual personal interests (Figure 1).

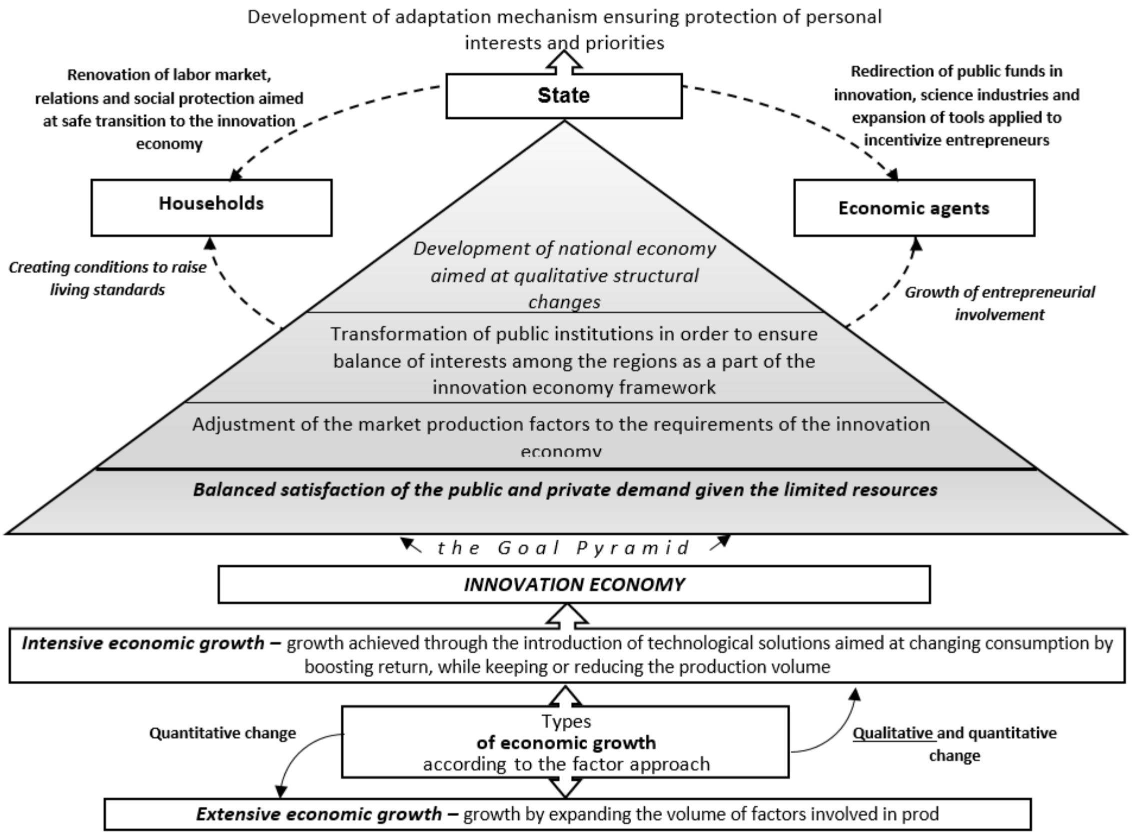


Figure 1. "Goal pyramid" of the innovation economy.

Obviously, the innovative interest of micro subjects is reflected in macroeconomic processes. The introduction of innovations in the activities of enterprises leads not only to the development of an effective individual development strategy (Leitão et al. 2020), an increase in their competitiveness in changing socio-economic conditions (Rotjanakorn et al. 2020), but also to the formation of a platform for the territory's innovation ecosystem (Huang et al. 2020).

The application of innovations requires the formation of favorable conditions (Baierle et al. 2021; Alvarez-Meaza et al. 2020). At the same time, in the context of interaction with the environment, innovations should be divided into two types: closed and open.

However, when introducing closed innovations, the internal potential of an economic entity is a priority (Turoń 2022b), and open innovations involve external interaction supported by a motivated exchange of specialists, technologies, and development results (Hernández-Dionis et al. 2022; Walter et al. 2021; Pereira et al. 2021; Didenko et al. 2021; Hizam-Hanafiah and Soomro 2021; de las Heras-Rosas and Herrera 2021; Valdez-Juárez and Castillo-Vergara 2020). When implementing this approach, the state of the environment (Chukhray et al. 2022; Prokop et al. 2021; Rudskaya et al. 2022; Ziakis et al. 2022) in which an innovatively active enterprise operates, acquires special significance. Speaking about the readiness of the external environment to implement the concept of open innovations, it is essential not only to provide resources, to but also the interest in innovations of all groups of economic entities, including public law entities (Ramírez-Montoya et al. 2022; Majid Gilani and Faccia 2021).

In this regard, the formation of the environment comes to the fore (Ziakis et al. 2022; Osorno-Hinojosa et al. 2022), including its organizational, legal, economic, social, technological, and other components, which contribute to the growth in the number of supporters of the open innovation concept. However, it is the actions of macro- and meso-actors (Yun et al. 2016; Liu 2021), given the regulatory function assigned to them in the field of economic relations, that are aimed at creating a favorable environment for innovative transformations. In addition, with the help of various tools of influence, they influence the behavior of micro subjects in the reproductive process. Thus, timely adjustment of the legal framework, development of relevant financial and tax incentives, ensuring socio-economic stability, other measures (Amrina et al. 2021; Franco-Riquelme and Rubalcaba 2021) implemented directly by public authorities (Cruz-Ruiz et al. 2022) are the foundation not only for the growth of innovative activity but also for the transition from closed to open innovation. In turn, open innovations bring positive benefits (Turoń 2022a; Tjahjadi et al. 2022; Tutak and Brodny 2022; Sabando-Vera et al. 2022; Roša (Rosha) and Lace (2021); Raya et al. 2021; Farmania et al. 2021) both for the producer and consumer and for the state (its administrative-territorial units) (Liu et al. 2022; Skordoulis et al. 2020), since the degree of satisfaction of individual needs is the basis of its well-being.

2.2. Assessment of Innovative Conditions Prevailing in Meso-Territories

Innovatization primarily captures the reproduction cycle and further determines the need for transformation in the institutional environment of the public legal entities represented by the country's administrative and territorial units. These changes shape the innovation climate—a platform for innovations. Nevertheless, the macro-goals of innovatization can never counter the capacity of meso actors, which is highly relevant for states with a high level of differentiation in the social and economic development within minor regions. The Russian Federation makes a striking example where numerous neighboring meso-territories create environments both favorable and unfavorable to innovation, thereby generally doubting the innovative attractiveness of the state. At the same time, the role of the meso level in disseminating innovations has not been adequately reflected in foreign scientific publications (McPhillips 2020). Scientists focus on micro- (Ibarra et al. 2018; Akdil et al. 2018; Erol et al. 2016; Müller et al. 2018a, 2018b; Christa et al. 2020) and macroeconomic subjects (Maresova et al. 2018; Beier et al. 2017; Povolná and Švarcová 2017; Chovancova et al. 2018; Oudgou 2021). This effect makes it particularly vital to study the region's innovation climate.

The innovation climate is a set of conditions (Golova 2007) that either promote or hinder the innovative transformation and involvement of economic entities, households, and public institutions within a region. This term in Russian studies is synonymous with the following definitions: "innovative conditions", "innovative environment", "innovative climate". In foreign scientific works, the innovation climate, as a rule, is considered in the context of firms (Sönmez and Yıldırım 2019; Afrin et al. 2022; Jamai et al. 2022). The content of this category is inextricably linked with improving the efficiency of companies by creating a favorable environment in them. In addition, some publications (Ji and Goo 2021) talk about the importance of the external social, economic, technological and other environments for doing business. By analogy, the "innovative climate" for the meso-territories should be interpreted as conditions conducive to increasing the innovative activity of all groups of economic entities.

Assessment of the innovation climate is carried out using statistical analysis methods. In this regard, scientific papers focus on different groups of criteria to evaluate the individual parameters of the innovative climate in a region, namely: scientific potential (Sukhovey and Golova 2020; Khachatryan 2020; Nesterenko and Tcukanov 2012), technological infrastructure (Prazdnichnykh 2013), availability of technological development factors (Dementyev 2013; Dementiev 2019), innovation activity (Bayev and Solovyova 2014; Golova and Sukhovey 2019; Doroshenko et al. 2020; Averina and Sirotin 2020), and state support for innovation initiatives (Abdikeev et al. 2018; Seidl da Fonseca 2018; Pakhomova and Tkachenko 2014), etc. Despite being well covered in scientific papers, the indicators describing certain components of a territorial and economic complex are not the only way to conduct the indicative analysis of the innovation climate. It can also be comprehensively analyzed based on a system of interrelated ratios, typical for public legal entities, for example, favorableness of environment, involvement of enterprises, performance (Bagrinovsky 2011; Pakhomova and Smirnov 2011), and integrated indices (Rudskaya and Rodionov

2017). In addition, regression analysis is used to identify interdependencies between the significant factors in innovation (Seidl da Fonseca 2017).

2.3. Formulation of the Research Hypothesis (the Case of Russia)

The indicative analysis is one of the popular tools for assessing socio-economic conditions at the macro, meso and micro levels (Sukhovey and Golova 2020; Dementiev 2019; Khachatryan 2020; Abdikeev et al. 2018; Seidl da Fonseca 2018; Liu 2021; Nesterenko and Tcukanov 2012; Prazdnichnykh 2013; Dementyev 2013; Bayev and Solovyova 2014; Golova and Sukhovey 2019; Doroshenko et al. 2020; Averina and Sirotin 2020; Pakhomova and Tkachenko 2014; Pakhomova and Smirnov 2011; Bagrinovsky 2011; Rudskaya and Rodionov 2017; Kim et al. 2021). However, it has disadvantages. The values of some indicators may indicate favorable innovative conditions, while others may indicate their absence. The set of visibility indicators can change; it can be expanded if there is information about each subject included in the aggregate sample, or narrowed, focusing only on criteria that reflect a specific aspect of innovative and technological transformations. Therefore, it is essential to use such a combination of indicators that will allow you to characterize the phenomenon under consideration in dynamics comprehensively. However, sometimes, carefully selected indicators can distort the real picture. For this reason, to increase the objectivity of calculations, emphasis is often placed on maximizing the number of visibility indicators. This approach leads to the complication of evaluation procedures: the more quantitative parameters are selected, the more difficult it is to formulate a qualitative characteristic.

It is sufficient that the combination of variables in the adjusted rate ratio can be either expanded if the information about each actor is available in the general sample or narrowed down to a small number of criteria reflecting a specific aspect of the innovative and technological transformations. At the same time, the absolute comparison proves to be impractical in the assessment of the favorable or unfavorable innovation climate because the Russian regions are not comparable in many parameters, such as geographical location and size, climate, the proximity of borders, population, economic realms, etc. (Zemtsov and Smelov 2018). However, in some cases, objective assessment of the innovation processes is impossible even when applying relative indicators. It is especially relevant for the regions where a certain social and economic alienation is observed, which makes it either a leader among other meso-territories or an outsider. For instance, the financial centers (Moscow, St. Petersburg), the educational "capitals" (Moscow, St. Petersburg, Rep. Tatarstan), and the cities of science (Moscow, St. Petersburg, Moscow region, Novosibirsk Region, etc.), undoubtedly have advantages over other regions, in particular, when dealing with the innovatization of financial and economic activities.

And on the contrary, the regions with a high unemployment rate, low income and the subsequent outflow of their population, which forms the labor foundation of a territory, tend to lose attractiveness for innovation. Thereby, the calculation of relative indicators with the GRP (a key indicator of a territory's efficiency) taken as the basis of comparison is not comprehensive and, as a result, the accurate economic "picture" in the regions gets distorted because a larger denominator produces a lower target value and vice versa. Recalculation of per capita indicators, primarily the cost ones, is not always reasonable since a significant decrease in population can be accompanied by depreciation of the federal money. A similar situation is possible when calculating integral indices generally consisting of absolute (relative) statistical quantities. In their turn, regression equations show different results because they allow for the detection of interrelations and interdependencies between a whole number of economic indicators, which contributes to the transparent assessment of economic processes occurring in the meso-territories.

Following the arguments above, it is important to adjust the assessment results obtained by tracking the dynamics of the economic indicators using the conventional Cobb—Douglas production function (Kirilyuk 2013; Vaseyskaya and Glukhov 2019; Suvorov et al. 2020; Samoilova et al. 2021; Usman et al. 2021; Suwandaru et al. 2021; Quezada-Téllez et al.

2021; Khadim et al. 2021). The efficiency of this function is confirmed by the specifics of predictors represented by a dynamic series of statistical variables reflecting changes over time. Such a tracking method allows for establishing typical long-term patterns, while the regression equation is especially accurate and reliable when the number of control points is quite high. So, due to the stagnancy of economic relations caused by quite a relative "consistency" of demand and resources allocated to meet it, the observed functional dependence is more likely to reveal the current production trend rather than the yearly absolute, and relative analysis is. The annual change in priorities, resulting from the internal and external impact on the regions, provokes the redirection of financial and other material resources to the sectors associated with short-term development benchmarks, thus, leading to significant fluctuations in the social and economic indicators.

In general, the regression equation described above aims to increase the reliability of the innovation assessment in the meso-territories.

In addition, it is appropriate to use this functional dependence to assess innovative conditions for several other reasons:

- Analysis of the values of the calculated coefficients of the model will make it possible to establish which factors of production have the most significant impact on returns to scale.
- The values of the calculated coefficients of the model indirectly indicate the type of economic growth inherent in the economic entity. The extensive type indicates low innovative activity, which hinders the development of open innovations. The intensive type indicates a predisposition to innovative transformations.
- By the value of the model constant, one can judge how much the resulting indicator depends on factors not taken into account in the structure of the regression equation, including neutral scientific and technological progress.
- In some cases, the component composition of the Cobb–Douglas function model can be expanded by adding predictors, which is advisable when identifying the impact on the resulting indicator of any unaccounted-for factor in its classical version, for example, open innovations.

Since such a use of the named variety of the regression equation is aimed at increasing the objectivity of assessing the innovative climate of macro- and meso-formations, this study is devoted to testing the following hypotheses:

Hypothesis 1. *The classical production function can be used as an independent tool for assessing innovative conditions in meso-territories.*

Hypothesis 2. *The classical production function is not suitable for estimating innovative conditions in meso-territories.*

Hypothesis 3. *The classical production function should be used as an additional tool for assessing innovative conditions in meso-territories.*

Hypothesis 4. *The calculation of the classical production may precede an in-depth analysis of the innovation environment.*

Thus, determining the degree of favorable (unfavorable) innovative conditions is essential for identifying opportunities for various groups of economic entities to support innovation, including open ones.

3. Methods

The study aims to test the hypothesis about the possibility of using the production function as a tool for assessing the innovation climate in Russian regions. Therefore, first, an analysis of indicators characterizing the innovative conditions in the federation subjects was carried out. A production function is then calculated to compare further the results obtained with different analysis tools. To test the hypothesis, it is advisable to compare the effects of using at least two different analysis tools: indicative analysis (a typical tool for assessing innovative conditions) and regression analysis (the construction of a production function is based on this method).

3.1. Basic Research Methods: Rationale for Choice

Indicative analysis as the primary research method is relevant to assessing the socio-economic conditions for the functioning of macro, meso, and micro subjects (Sukhovey and Golova 2020; Dementiev 2019; Khachatryan 2020; Abdikeev et al. 2018; Seidl da Fonseca 2018; Liu 2021; Nesterenko and Tcukanov 2012; Prazdnichnykh 2013; Dementyev 2013; Bayev and Solovyova 2014; Golova and Sukhovey 2019; Doroshenko et al. 2020; Averina and Sirotin 2020; Pakhomova and Tkachenko 2014; Pakhomova and Smirnov 2011; Bagrinovsky 2011; Rudskaya and Rodionov 2017; Kim et al. 2021). As a rule, each of the listed groups of actors is characterized by a set of indicators. The results of the indicative analysis were used as a "comparison platform" with the results of the constructed models of the Cobb–Douglas function to confirm (refute) the formulated hypotheses.

Auxiliary research methods included absolute and relative statistical values, indices, interquartile range, and dynamics series. Their use was aimed at the selection, processing of initial data, generalization, and compact presentation of the results of calculations.

3.2. Relative Statistical Numbers (Adjusted Rate, Indices)

Key parameters for the innovation climate to be considered as favorable or unfavorable include the following: availability of economic resources—capital, labor, technologies, information—the foundation for any innovative transformations; involvement of government and authorities in support of the innovation initiatives—regulatory mechanism of the innovation economy; and public demand for innovation—motivational factor of the innovation activity. It should be noted that the system of coefficients is built taking into account the data accumulated by the Federal State Statistics Service; since the indicators of official statistics are not unified within the world community, using evaluation criteria in other countries is impossible due to the lack of such information in the context of Russian regions.

This approach is consistent with the above analysis of scientific publications.

Three sets of indicators presented in Table 1 allow determining the region's position in the general sample (83 regions) in terms of more/less favorable innovation climate:

- The first set defines the resource potential of the region with an emphasis on such production factors as capital (physical and real), labor, technologies, information (as an element of product promotion). Without economic resources, it is impossible to create an economic good, which is necessary to meet the needs of individuals. This means that the availability of resources is an important condition for innovative transformations. Emphasis is placed on such resources as "capital" and "labor", as they are included in the production function. However, it is important to have a certain amount of these resources and their quality in the context of innovative transformations. Therefore, it is essential to assess the degree of depreciation of fixed assets and the volume of investments in fixed capital that contribute to its renewal. It is advisable to consider the provision of the territory with researchers to identify the effectiveness of their activities. It is also appropriate to characterize the availability of "technology" and "information". The availability of "information" was assessed indirectly through workers' access to personal computers, since it is personal computers that speed up the process of searching and exchanging information.
- The second set describes the indirect involvement of state institutions in the innovation changes through budget expenditures on the economy and labor market (detailed data on the innovation initiatives implemented at the request of regional authorities are lacking). At the same time, there are no data on the expenditure of funds for direct innovation in Russian regions. However, to a certain extent, spending on the terri-

tory's economy can contribute to innovative reforms. For example, the unemployed retraining should follow the renewal of fixed assets. Another indicator reflects how actively the authorities of the subject of the federation are fighting unemployment, including creating jobs. In the conditions of replacing a person with mechanisms, the released labor force must be employed, or the state will not guarantee the observance of such a right of citizens as the right to work. It should be noted that the above coefficients only indirectly characterize the authorities' involvement in innovative reforms. And they were applied due to the lack of more informative indicators in official statistics.

- The third set assesses the demand of economic entities and households for innovations. To calculate the indicators of the third block, the indicators presented by the Federal State Statistics Service were used, calculated by this body based on its methodology. In the article, these indicators formed the basis for calculating relative statistical values, making it possible to determine the subjects of the federation in which the need for innovative transformations is most pronounced.

Table 1. System of coefficients describing the innovation climate in a region (the authors developed the system of indicators).

Indicator Name	Calculation Formula	Standard Value
1. Availability of economic resources		
Capital		
1.1.1. Degree of depreciation of fixed assets: ratio of the region to the Russian Federation (I_1)	I_1 = (Degree of depreciation of fixed assets in the region)/(Degree of depreciation of fixed assets in Russia)	Specified value < 1. Assesses the physical capital, its readiness to be used and the need for renovation.
1.1.2. Investments in fixed assets: ratio of the region to the Russian Federation (I_2)	I_2 = (Investments in fixed assets in the region (per worker))/(Investments in fixed assets in Russia (per worker))	Specified value ≥ 1. Defines the investment activity—indirect stimulation of the innovation processes.
Labor		
1.2.1. Number of workers involved in scientific research and development to total employment: ratio of the region to the Russian Federation (I_3)	I_3 = (Number of workers involved in scientific research and development to total employment in the region)/(Number of workers involved in scientific research and development to total employment in Russia)	Specified value ≥ 1. Reflects the availability of scientific staff responsible for the important innovative and technological changes in the economy.
1.2.2. Patent applications filed for inventions per 1000 workers engaged in scientific research and development: ration of the region to the Russian Federation (I_4)	I_4 = (Patent applications filed for inventions per 1000 workers engaged in scientific research and development in the region)/(Patent applications filed for inventions per 1000 workers involved in scientific research and development in Russia)	Specified value ≥ 1. Indirectly characterizes the labor productivity of workers employed in the research and development sector.
Technologies		
1.3.1. Issued patent applications for inventions per 1000 workers engaged in scientific research and development: ratio of the region to the Russian Federation (I_5)	I_5 = (Issued patent applications for inventions per 1000 workers engaged in scientific research and development in the region)/(Issued patent applications for inventions per 1000 workers involved in scientific research and development in Russia)	Specified value ≥ 1. Specifies effectiveness of the research and development sector.
Information		
1.4.1. Number of personal computers per 100 employees: ratio of the region to the Russian Federation (I_6)	I_6 = (Number of personal computers per 100 employees in the region)/(Number of personal computers per 100 employees in Russia)	Specified value ≥ 1. Indirectly specifies the level of availability of information and telecommunications technologies.

Table 1. *Cont.*

Indicator Name	Calculation Formula	Standard Value
2. Involvement of government and authorities in support of the innovation initiatives (indirect impact)		
Support of the regional economy through budget expenditures		
2.1. Expenditures on the economy (per capita): ratio of the region to the Russian Federation (I_7)	I_7 = (Expenditures on the economy in the region (per capita))/(Expenditures on the economy in Russia (per capita))	Specified value ≥ 1. Reflects the volume of money allocated from the budget funds in the regional economy (in terms of meeting the population needs)—indirectly stimulating employment, entrepreneurial activity, innovation processes.
Labor supply		
2.2. Unemployment load represented by the citizens registered with the employment services (per one vacant position): ratio of the region to the Russian Federation (I_8)	I_8 = (Unemployment load represented by the citizens registered with the employment services (per one vacant position) in the region)/(Unemployment load represented by the citizens registered with the employment services (per one vacant position) in Russia)	Specified value < 1. Indirectly describes the region's employment policy, which is an important indicator to track in terms of automation when people are vastly replaced by technologies.
3. General need for innovation		
Need of enterprises for the cutting-edge technologies		
3.1. Level of innovation activity in enterprises: ratio of the region to the Russian Federation (I_9)	I_9 = (Level of innovation activity in enterprises in the region)/(Level of innovation activity in enterprises in Russia)	Specified value ≥ 1. Reflects the degree of the enterprises' involvement in innovations in the region.
3.2. Advanced production technologies (per worker): ratio of the region the Russian Federation (I_{10})	I_{10} = (Advanced production technologies used in the region (per worker))/(Advanced production technologies used in Russia (per worker))	Specified value ≥ 1. Defines the level of prevalence of advanced production technologies in the enterprise's activities.
End-user's interest in innovation		
3.3. Volume of innovative goods and services (per capita): ratio of the region to the Russian Federation (I_{11})	I_{11} = (Volume of innovative goods and services in the region (per capita))/(Volume of innovative goods and services in Russia (per capita))	Specified value ≥ 1. Indicates the interest of end-users in innovation.

Since meso-territories tend to develop unevenly, strongly depend on federal financial support and annually change the budget planning priorities, calculating indicators should be carried out for more than a year to identify any medium or long-term trends.

3.3. Interquartile Range

The interquartile range is used to assess the degree of similarity between the regions regarding favorable or unfavorable innovation climates. Quartiles calculation is based on the regions ranking, with the adjusted rate for the period of 2009–2018 taken as a benchmark (Table 1). The regions were ranked in accordance with the indicators (for each year). The highest indicator ranked 1st, while the lowest—83rd, with the mid-rank identified for the 10 years:

$$MR\ (I) = \frac{\sum_{t=1}^{T} R\ (I)_t}{T} \tag{1}$$

where

MR (*I*) is mid-rank *I* for the research period as a whole *T*;

R (*I*) is a rank according to the year indicator *t*.

To assess the entire set of factors shaping the innovation climate in the region, the overall rank is calculated according to the set of adjusted rates:

$$OR = \frac{\sum_{i=1}^{n} MR(I)_i}{n} \tag{2}$$

where

OR is the overall rank based on all indicators;

MR (*I*) is a mid-rank according to the indicator *I* for the research period *T* as a whole;

i is an ordinal number of the indicator (varies from 1 to *n*).

Based on the overall rank value obtained for each region according to the set of indicators, the meso-territories were divided into quartiles-Q_1-Q_4 (3) to determine similarities in their innovation climate. The results were visually represented via the boxplot.

$$Q_1 = (N+1) * \frac{1}{4};\ Q_2 = (N+1) * \frac{1}{2}; Q_3 = (N+1) * \frac{3}{4} \tag{3}$$

where

N is a sample scope.

Formula (3) is used for an odd value of the sample scope.

3.4. Production Function

This study implemented the classic production function based on input and output indicators:

$$Y = A * K^{\alpha} * L^{\beta} \tag{4}$$

where

Y is a gross regional product, million rubles;

K is "capital" (average annual cost of funds, million rubles);

L is "labor" (labor costs, million rubles);

A is a constant (describes the influence of factors not included in the model, e.g., scientific and technological progress);

α and β are elasticity coefficients for "capital" and "labor", respectively.

The benchmark data of the model are given by value at current prices, due to the lack of data on the index of the physical volume of fixed assets for the entire sample. What is more, the traditional production function for "labor" is the actual labor costs calculated in man-hours, though such statistics cannot be provided by the regions. Nonetheless, it is totally unacceptable to substitute the indicator mentioned above by the employment rate, since it does not take into account the real labor costs of the population (actual working hours), although it is essential in the conditions of increasing internal and external plurality that leads to the workload increase per employee. In this regard, the cost assessment of "labor" separately allows for determining the employee's workload because wages depend on the amount of work performed—an extensive component, and on the employee's qualifications—an intensive element. This is why it is advisable to consider "labor" with due regard to its costs—a combination of wages and payments to non-budgetary funds.

Production function based on the growth rate ratio is:

$$y_t = \alpha * k_t + \beta * l_t + \gamma \tag{5}$$

where

y_t, k_t, l_t are discrete growth rates of GRP, the average annual cost of fixed assets, and labor costs, respectively;

γ is the rate of neutral technical progress.

The usefulness of applying the term "ecosystem" to biological as well as any socio-economic systems is based on the similarity of structure, functions, operational principles and conditions for interactions and resource exchange with the outside.

4. Results

4.1. Results of Calculating the Adjusted Rate Indicators (I_1–I_{11})

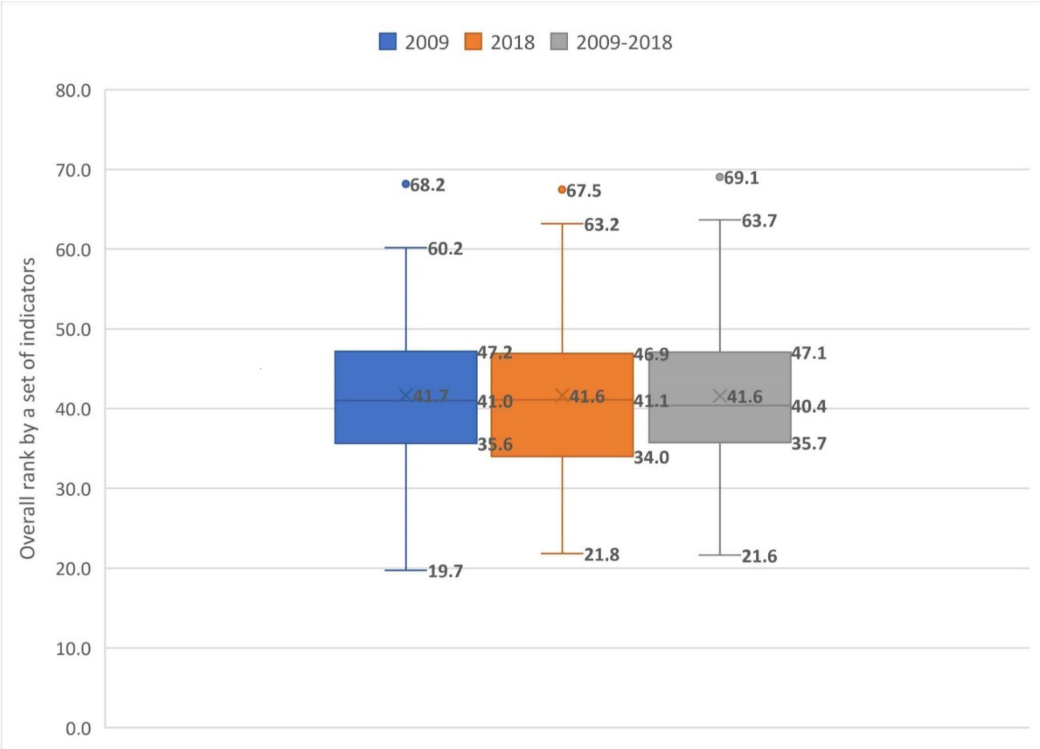
The rates from Table 1 (2009–2018) were calculated for 83 regions included in the sample pool, except for Sevastopol, Crimea due to the lack of data up to 2014. The results of the calculation were used for ranking (Table 2).

Table 2. Regions are classified by quartiles Q_1 and Q_4 on ranking by a set of adjusted rates.

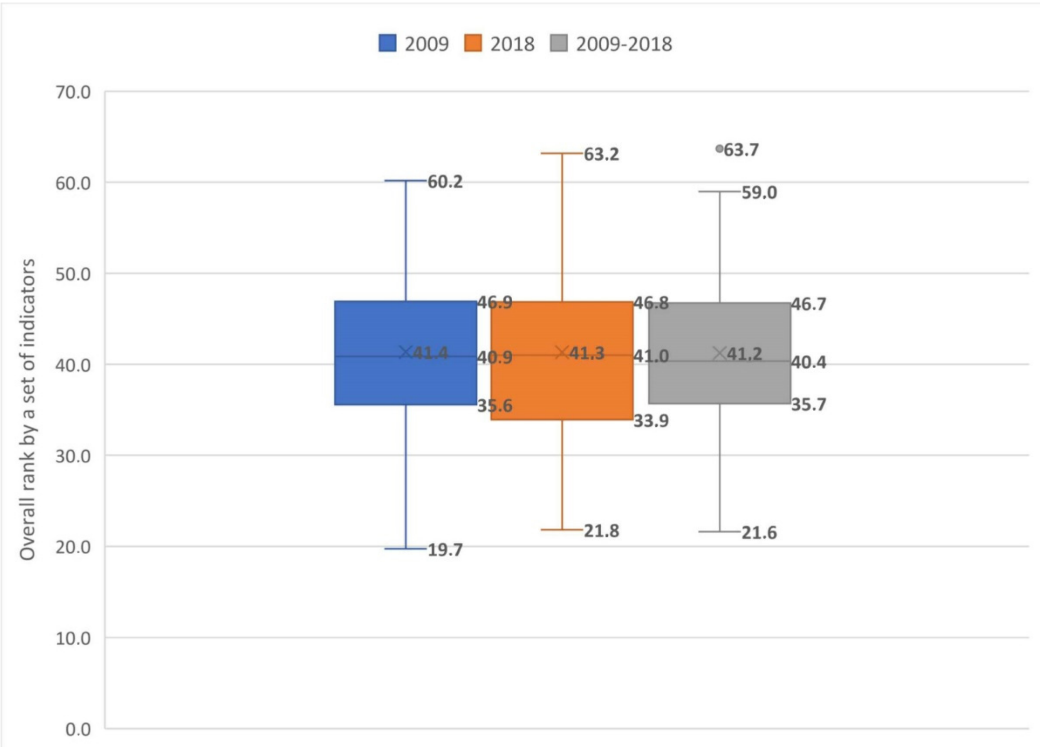
2009 (Overall Rank According to the Set of Indicators)	**2018 (Overall Rank According to the Set of Indicators)**	**Average for the Period from 2009 to 2018 (Overall Rank According to the Set of Indicators)**
Quartile—Q_1 Moscow; Tomsk Region; St. Petersburg; Lipetsk Region; Khabarovsk Territory; Rep. Tatarstan; Magadan Region; Krasnoyarsk Region; Primorsky Region; Nizhny Novgorod Region; Yamalo–Nenets Autonomous District; Vologda Region; Kaluga Region; Belgorod Region; Perm Region; Moscow Region; Rep. Bashkortostan; Novgorod Region; Tambov region; Yaroslavl Region; Kostroma Region.	Quartile—Q_1 Rep. Tatarstan; Belgorod Region; Lipetsk Region; Moscow Region; Yamalo–Nenets Autonomous District; Moscow; Khabarovsk Region; Kaluga Region; Tyumen Region; St. Petersburg; Tambov Region; Krasnoyarsk Region; Tula Region; Kursk Region; Voronezh Region; Rep. Bashkortostan; Rep. Mordovia; Chuvash Republic; Tver Region; Leningrad Region; Vologda Region.	Quartile—Q_1 Moscow; Rep. Tatarstan; Khabarovsk Region; St. Petersburg; Lipetsk Region; Magadan Region; Kaluga Region; Tomsk Region; Yamalo–Nenets Autonomous District; Belgorod Region; Krasnoyarsk Region; Nizhny Novgorod Region; Vologda Region; Rep. Mordovia; Voronezh Region; Tula Region; Moscow Region; Chuvash Republic; Rep. Bashkortostan; Perm Region; Tyumen Region.
Quartile—Q_4 Orenburg Region; Rep. Karelia; Smolensk Region; Altai Region; Stavropol Region; Trans-Baikal Region; Rep. Komi; Kemerovo Region; Bryansk Region; Rep. Adygea; Rep. Khakassia; Rep. Mari El; Rep. Altai; Kabardino-Balkarian Rep; Rep. Tyva; Karachay–Cherkess Republic; Rep. North Ossetia; Chechen Republic; Rep. Kalmykia.	Quartile—Q_4 Astrakhan Region; Orenburg Region; Rep. Karelia; Ivanovo Region; Altai Region; Stavropol Region; Rep. Buryatia; Rep. Kalmykia; Nenets Autonomous District; Trans-Baikal Territory; Rep. Altai; Rep. North Ossetia; Rep. Khakassia; Kabardino-Balkar Republic; Jewish Autonomous Region; Rep. Dagestan; Karachay–Cherkess Republic; Rep. Tyva; Chechen Rep.	Quartile—Q_4 Kemerovo Region; Zabaykalsky Region; Rep. Altai; Orenburg Region; Altai Region; Smolensk Region; Stavropol Region; Rep. Karelia; Kurgan Region; Nenets Autonomous District; Kabardino-Balkar Republic; Rep. Dagestan; Rep. Khakassia; Rep. Adygea; Rep. Kalmykia; Rep. North Ossetia; Rep. Tyva; Karachay–Cherkess Republic; Chechen Republic.
Outlier: Rep. Ingushetia	Outlier: Rep. Ingushetia	Outlier: Rep. Ingushetia

According to the data provided in Table 2, significant shifts can be observed in the list of regions included in the Q_1 quartile (about 40% of all regions ever taking the leading position lost it by 2018—Tomsk Region; Magadan Region; Primorsky Region; Nizhny Novgorod Region; Perm Region; Novgorod Region; Yaroslavl Region; Kostroma Region), while the composition of the Q_4 quartile turned out to be slightly more stable (only one third of all regions were ranked higher). Figure 2 presents the scale graph (boxplot) to determine the degree of dispersion in regions by a set of coefficients characterizing the innovation climate (Figure 2a,b).

According to the visualization of quartiles, a reduction of dispersion among the meso-territories is observed in 2018. Thus, the value of the highest overall rank decreased from 19.7 in 2009 to 21.8 2018, while the value of the lowest overall rank increased from 68.2 in 2009 to 67.5 in 2018. This observation proves the regional policy's effectiveness aimed at reducing the differentiation level in terms of social and economic development in the mesic territories. However, 2018 is marked by a severe gap, which reveals the degree of dispersion of the Q_4 regions reflecting a growing scale of the given group. When Ingushetia becomes an outlier, the Q_4 structure (2009–2018) changes, introducing another outlier—the Chechen Republic. Significantly enough, when no outliers appear, the boxplot becomes "tighter" which reflects growing similarities among the meso-territories in terms of the adjusted rates.



(**a**) Including Ingushetia



(**b**) Excluding Ingushetia

Figure 2. Scale graph (boxplot)—visual representation of quartiles including the regions selected in the ranking by the adjusted rate indicators.

4.2. Specification of the Results of Calculating the Production Function Based on the Input–Output and Growth Rate Indicators

Identification of interdependence between the GRP and such production factors as capital, labor, and technology is possible through the Cobb—Douglas production function based on input–output and growth rate indicators. To do so, the individual models of this function were developed for each of the 83 regions, except for Sevastopol, Crimea. (Tables 3 and 4). Description of their quality is provided in Table 3.

Table 3. Quality parameters of production function models developed for 83 regions (*).

Production Function Based on the Input–Output Indicators	**Production Function Based on the Growth Rate Indicators**
$Y = A * K^{\alpha} * L^{\beta}$	$y_t = \alpha * k_t + \beta * l_t + \gamma$
Determination coefficient (R-square)	
- Bottom value—0.956 (Kalmykia); - Peak value—0.998 (Kaluga Region, Pskov Region, Krasnodar Region, Stavropol Region, Ulyanovsk Region, Rep. Tyva); - High accuracy in the fitting of the regression equation.	- Bottom value—0.035 (Nenets Autonomous District); - Peak value—0.765 (Novosibirsk Region); - for 24 R-square models < 0.5, which implies the insufficient nature of dual regression due to the other factors affecting the final indicator; - for 49 models 0.5 < R-square < 0.7, indicating the satisfactory accuracy of the equation fitting; - for 10 built models (Bryansk region, Kaluga Region, Tula Region, Pskov Region, Krasnodar Region, Rep. Tatarstan, Chuvash Republic, Chelyabinsk Region, Novosibirsk Region, Tomsk Region) R-square > 0.7—the fitting accuracy of the regression equation is high.
F-test	
- Bottom value—173 (Kalmykia); - Peak value—4476 (Kaluga Region); - The F-test value for all constructed models is several orders greater than the tabular value (F-test = 3.63, a = 0.05)—hypothesis on the random nature of the estimated parameters is rejected, their statistical significance is recognized.	- Bottom value—0.274 (Nenets Autonomous District); - Peak value—25.978 (Novosibirsk Region); - The F-test value for 73 constructed models is higher than the tabular value (F-test = 3.63, a = 0.05)—hypothesis on the random nature of the estimated parameters is rejected, their statistical significance is recognized; - The F-test value for 10 constructed models is lower than the tabular value (Nenets Autonomous District, Vologda Region, Murmansk Region, Rep. Adygea, Rep. Ingushetia, Khanty-Mansi Autonomous Region, Kamchatka Region, Amur Region, Magadan Region, Sakhalin Region)—hypothesis on the random nature of the estimated parameters is not rejected and their statistical significance is doubted.
The Durbin-Watson test (the DW test)	
- Lack of autocorrelation: The Durbin-Watson test at a 5% significance level belongs to the interval—[1.53; 2.47]. The Durbin–Watson test corresponds to the tabular value in the models constructed for 19 regions; - Lack of autocorrelation: The Durbin–Watson test at a 1% significance level belongs to the interval—[1.26; 2.74]. The Durbin–Watson test corresponds to the tabular value in the models constructed for 39 regions; - For models without an intercept is not considered representative.	- Lack of autocorrelation: The Durbin–Watson test at a 5% significance level belongs to the interval—[1.53; 2.47]. The Durbin–Watson test corresponds to the tabular value in the models constructed for 57 regions; - Lack of autocorrelation: The Durbin–Watson test at a 1% significance level belongs to the interval—[1.26; 2.74]. The Durbin–Watson test corresponds to the tabular value in the models constructed for 74 regions; - For the Durbin–Watson test, at a 5% significance level, the following uncertainty zones are distinguished (1.08; 1.53) and (2.47; 2.92), while at a 1% significance level—(0.83; 1.26) and (2.74; 3.17). For 82 regions (5% significance level) and 83 regions (1% significance level) of the constructed models, this parameter either corresponds to a tabular value or belongs to an uncertainty zone. Consequently, at a 5% significance level, the positive autocorrelation of residuals in the model constructed for Tyumen Region is confirmed, but at a 1% significance level, it is impossible to make an unambiguous judgment on the presence of positive or negative autocorrelation.

Table 3. *Cont.*

Production Function Based on the Input–Output Indicators	Production Function Based on the Growth Rate Indicators
$Y = A * K^{\alpha} * L^{\beta}$	$y_t = \alpha * k_t + \beta * l_t + \gamma$
The Student's *t*-test	
- Models developed for 41 regions reflect the systematic influence of both, "capital" and "labor" on the final indicator at a 5% significance level; - Models developed for 5 regions reflect the systematic influence of "capital" only on the final indicator at a 5% significance level (Smolensk Region, Rep. Karelia, Astrakhan Region, Chechen Republic, Magadan Region); - Models developed for 32 regions reflect the systematic influence of "labor" only on the final indicator at a 5% significance level; - Models developed for 5 regions reflect no systematic influence on the final indicator at a 5% significance level, either on "capital", or "labor" (Lipetsk Region, Vologda Region, Rep. Kalmykia, Tyumen Region, Khanty-Mansiysk Autonomous Region); - Models developed for 39 regions reflect the systematic impact of the (A) constant on the final indicator at a 5% significance level; - Models developed for 18 regions reflect the systematic impact of three factor group, including "capital", "labor", and "omitted", on the final indicator at a 5% significance level.	- Models developed for 2 regions (Kalmykia and Altai Region) reflect the systematic impact of two predictors, including "discrete growth rate of capital" and "discrete growth rate of labor", on the final indicator at a 5% significance level. As the results show, the model developed for Kalmykia cannot be adequately interpreted due to the negative coefficient at a discrete rate of increase in the value of fixed assets. The model built for Altai Republic, in its turn, fails to meet the quality parameters due to the low R-square value; - Models developed for 60 regions (more than a half managed to fit all quality parameters) reflect the systematic impact of one predictor at a 5% significance level—"discrete growth rate of labor", while one region (Chechen Republic) is represented by "discrete growth rate of labor"; - Models developed for 2 regions (Kamchatka Region, Magadan Region) reflect the systematic influence of a free term (γ) on a final indicator at a 5% significance level, though they should not be considered due to the lack of reliability; - Models developed for 2 regions (Tula Region, Krasnoyarsk Region) reflect the systematic influence of a "discrete growth rate of capital", a "discrete growth rate of labor" and a free term on the final indicator at a 5% significance level. Nonetheless, these models cannot be adequately interpreted due to the negative coefficient at a discrete growth rate of fixed assets.

(*) research period for 82 regions—2000–2018 (2001–2018—function based on the growth rate indicators for Nenets Autonomous District, Khanty-Mansi Autonomous District, Yamalo–Nenets Autonomous District); research period for Chechen Republic—2009–2018.

Table 4. Specification of the calculated coefficients of the production function models.

Production Function Based on the Input–Output Indicators			Production Function Based on the Growth Rate Indicators	
Regions where $\alpha > \beta$		Regions where $\alpha < \beta$	Regions where $\alpha > \beta$	Regions where $\alpha < \beta$
19 regions (Bryansk Region; Voronezh Region; Orel Region; Smolensk Region; Tambov Region; Rep. Karelia; Pskov Region; Rep. Kalmykia; Astrakhan Region; Rep. Ingushetia; Chechen Republic; Rep. Mordovia; Udmurt Republic; Nizhny Novgorod Region; Saratov Region; Rep. Khakassia; Novosibirsk Region; Rep. Sakha; Magadan region)		64 regions	8 regions (Moscow Region; Orel Region; Tambov Region; Yaroslavl Region; Vologda Region; Rep. Dagestan; Chechen Republic; Yamalo–Nenets Autonomous District)	75 regions
Regions where $A > 1$	Regions where $A \approx 1$ (*)	Regions where $0 < A < 1$	Regions where $\gamma > 0$	Regions where $\gamma < 0$
41 regions	Sverdlovsk Region—A = 1.002; Altai Republic—A = 0.957	40 regions	72 regions	11 regions (Voronezh Region, Kaluga Region; Lipetsk Rep; Moscow; Tambov Region; Moscow; Volgograd Region; Dagestan; Chechen Republic; Chelyabinsk Region; Omsk Region)

Table 4. *Cont.*

Production Function Based on the Input–Output Indicators		**Production Function Based on the Growth Rate Indicators**
Regions where $\alpha + \beta \geq 1$	Regions where $\alpha + \beta < 1$	
39 regions (Belgorod Region; Bryansk Region; Vladimir Region; Voronezh Region; Kaluga Region; Kursk Region; Orel Region; Smolensk Region; Tambov Region; Tula Region; Rep. Karelia.; Arkhangelsk Region; Kaliningrad Region; Novgorod Region; Pskov Region; Rep. Adygea; Rep. Kalmykia; Astrakhan Region; Rostov Region; Chechen Republic; Rep. Mari El; Rep. Mordovia; Udmurt Republic; Kirov Region; Penza Region; Saratov Region; Kurgan Region; Sverdlovsk Region; Yamalo–Nenets Autonomous District; Rep. Tyva; Rep. Khakassia; Krasnoyarsk Region; Irkutsk Region; Novosibirsk Region; Kamchatka Region; Khabarovsk Region; Magadan Region; Sakhalin Region; Chukotka Autonomous District)	44 regions	
Regions where all the parameters of the model quality meet the specified indicator (**) and the calculated coefficients are justified		
Ivanovo Region: Y = 1.591*$K^{0.317}$*$L^{0.62}$; Kursk Region: Y = 0.342*$K^{0.399}$*$L^{0.69}$; Oryol Region: Y = 0.216*$K^{0.795}$*$L^{0.294}$; Nenets Autonomous District: Y = 3.03*$K^{0.294}$*$L^{0.698}$; Kaliningrad Region: Y = 0.722*$K^{0.4}$*$L^{0.631}$; Novgorod Region: Y = 0.765*$K^{0.437}$*$L^{0.584}$; Stavropol Region: Y = 0.744*$K^{0.49}$*$L^{0.509}$; Rep. Mari El: Y = 0.168*$K^{0.455}$*$L^{0.683}$; Kirov Region.: Y = 0.381*$K^{0.464}$*$L^{0.588}$; Saratov Region: Y = 0.455*$K^{0.57}$6*$L^{0.455}$; Kurgan Region.: Y = 0.764*$K^{0.363}$*$L^{0.641}$; Rep. Altai: Y = 0.957*$K^{0.338}$*$L^{0.652}$; Rep. Tyva: Y = 0.91*$K^{0.206}$*$L^{0.803}$; Khabarovsk Region: Y = 0.51*$K^{0.482}$*$L^{0.55}$		Vladimir Region: *y = 0.163*k + 0.501*l + 0.052;* Yaroslavl Region: *y = 0.609*k + 0.316*l + 0.028;* Arkhangelsk Region: *y = 0.177*k + 0.842*l + 0.002;* Saint Petersburg: *y = 0.365*k + 0.578*l + 0.004;* Krasnodar Region: *y = 0.018*k + 0.678*l + 0.035*; Rostov Region: *y = 0.181*k + 0.557*l + 0.038*; Karachay–Cherkess Republic: *y = 0.17*k + 0.668*l + 0.003; Rep.* Mordovia: *y = 0.122*k + 0.523*l + 0.04;* Rep. Tatarstan: *y = 0.047*k + 0.812*l + 0.01;* Chuvash Republic: *y = 0.271*k + 0.681*l + 0.003*; Perm Region: *y = 0.046*k + 0.739*l + 0.023*; Nizhny Novgorod Region: *y = 0.104*k + 0.679*l + 0.026*; Ulyanovsk Region: *y = 0.31*k + 0.542*l + 0.015*; Yamalo–Nenets Autonomous District: *y = 0.257*k + 0.123*l + 0.113*; Altai Region: *y = 0.046*k + 0.78*l + 0.016*; Tomsk Region: *y = 0.022*k + 0.806*l + 0.017*; Rep. Buryatia: *y = 0.161*k + 0.677*l + 0.006*
Regions with the unjustified calculated coefficients		
Negative sign goes with the capital elasticity coefficient is observed in the models of the following regions: Yaroslavl Region; Volgograd Region; Rep. Dagestan; Karachay–Cherkess Republic; North Ossetia; Chuvash Republic; Perm Region; Orenburg Region; Rep. Buryatia; Kemerovo Region; Omsk Region; Tomsk Region.		*Negative sign* goes with the coefficient of "discrete growth rate of capital" in the models developed for 33 regions; *Negative sign* goes with the coefficient of "discrete growth rate of labor" in the models developed for 2 regions, including Ingushetia, Chechen Republic.; *Negative sign* goes with the free term describing other factors, including neutral technical progress, in the models developed for 11 regions

(*) deviation is not more than ±5% from the unit. (**) excluding the systematic influence of the constant in the model of the production function based on the input–output indicators; excluding the systematic influence of the discrete growth rates of "capital", "labor", and a free term in the model of the production function based on the growth rate indicators.

Two quality parameters of the developed models correspond to the norm in the production function based on input–output indicators, including the determination coefficient and the F-test. These tests turned out to be the most important ones when evaluating the reliability of the model. The determination coefficient proves the presented model structure to be the most appropriate (explained variable is interpreted by the given set of predictors in more than 95% of cases) and does not need to be expanded. In its turn, statistical significance of the equation is highlighted by the drastic difference between the tabular and calculated F-test. However, the calculated Student's *t*-test which reflects the systematic influence of capital, labor, and other factors omitted on the final indicator, is either higher or equal to the critical benchmark only in the fifth part of the calculated functional dependencies. However, for 80 models at least one of these predictors is significant (except for Lipetsk region, Kalmykia, and Tyumen region). When it comes to applying the Durbin–Watson test to determine whether the regression equation fits, it is appropriate if a free term is present in the model, which is not typical for the production function under consideration. Therefore, it is not necessary to focus on this quality parameter.

The production function based on the growth rate indicators, in general, is characterized by the low quality of models in one or more parameters. The determination coefficient lower than 0.7 indicates that the number of predictors in the regression equation is insufficient, which requires the additional introduction of independent variables into the model, thus, violating the structure of the Cobb–Douglas production function. A similar situation occurs with the Student's *t*-test. When its value is lower than tabular, removing a predictor that does not affect the dependent variable from the regression equation is necessary.

When assessing the models of the production function based on the input–output indicators that meet all the quality criteria listed earlier—14 out of the 83 regression equations—it is important to consider the fact that the structure of 11 regions shows that the elasticity coefficient for labor is higher than the elasticity coefficient for capital. This matter indicates an extensive type of economic growth that is not typically referred to as the intensification of production. The constant, including the one representing neutral scientific and technological progress, approximates or exceeds the unit only in three models, meaning that investments in capital, technology, and other factors are less important for specific regions.

If we ignore the Durbin–Watson test, we can see 22 "relatively satisfactory" regression equations, and the other 11 have a similar ratio of elasticity coefficients—$\alpha < \beta$. This leads to a conclusion that 22 functional dependencies out of 36 (satisfactory and relatively satisfactory) classify the economic growth as extensive in the following regions: Ivanovo Region; Kursk Region; Nenets Autonomous District; Kaliningrad Region; Novgorod Region; Rep. Mari El; Kirov Region; Kurgan Region; Rep. Altai; Rep. Tyva; Khabarovsk Region; Vladimir Region; Kaluga Region; Tver Region; Tula Region; Arkhangelsk Region; Rep. Adygea; Krasnodar Region; Rostov Region; Penza Region; Sverdlovsk Region; and Kamchatka Region.

When developing a production function model based on the input–output indicators, the initial data describing "labor" included labor costs, such as wages and payments to non-budgetary funds. On the one hand, this approach reflects the qualifications contributing to the worker's performance. On the other hand, it demonstrates labor costs produced by both intensive and extensive components, which is essential with the lack of information on the number of man hours. Therefore, it is impossible to conclude that the high elasticity coefficient for labor is explained by increasing labor productivity (Table 5). For example, Table 5 presents calculations on labor intensification in two regions—Belgorod and Sakhalin regions. These regions are observed individually because the higher elasticity coefficient for labor characterizes their regression equations. In contrast, the elasticity coefficient is positive, unlike other mesic regions with a negative coefficient.

Table 5. Indicators characterizing the intensification of labor in the Belgorod and Sakhalin regions.

Year	GRP Volume in Value Terms (Million Rubles) per Worker		Return on Each Ruble Spent on Labor		Nominal Salary, Calculated in US Dollars	
	Belgorod Region	Sakhalin Region	Belgorod Region	Sakhalin Region	Belgorod Region	Sakhalin Region
2000	0.4493	1.3739	2.6944	3.7942	61.02	130.80
2001	0.4554	1.5877	2.5399	4.2954	85.88	170.70
2002	0.4761	1.6852	2.2273	3.8121	111.43	221.99
2003	0.5152	1.9421	2.1033	3.7742	145.60	304.04
2004	0.5431	2.2565	2.0899	3.8534	183.42	406.49
2005	0.5799	2.4259	2.0011	3.6404	239.40	538.62
2006	0.6428	2.6624	1.9719	3.6222	306.84	693.49
2007	0.7193	3.2806	1.9220	3.9603	409.68	912.68
2008	0.7962	3.1160	1.8943	3.3054	543.38	1209.19
2009	0.8108	3.5144	2.0677	3.8874	441.75	1025.00
2010	0.8228	3.7423	1.9852	4.1395	524.97	1180.76
2011	0.9014	3.9032	1.9970	4.0435	601.16	1319.19
2012	0.9261	3.8135	1.9385	3.7393	643.56	1422.39
2013	0.9614	3.8708	1.9425	3.6531	697.68	1538.68
2014	1.0006	3.9181	2.0197	3.5283	618.88	1421.81
2015	1.0450	4.0718	2.2631	3.6741	416.83	1003.95
2016	1.0765	4.1191	2.3129	3.7168	409.97	983.04
2017	1.1147	3.9035	2.2923	3.4578	498.64	1175.10
2018	1.1506	4.2176	2.2157	3.3657	508.09	1236.23

According to Table 5, the volume of GRP in value terms per employee increased by more than 2.5 times in both regions from 2000 to 2018. Nonetheless, the return on each ruble invested in labor resources varied greatly in 2000–2018, with a significant decline over the period. In addition, "labor" seems to have been significantly underestimated in the early 2000s, as indicated by the nominal salary calculated in US dollars: the value tends to move upward and from 2000 to 2018 it grew 8–9 times. The real value in US dollars also increased, but not so significantly—1.5–1.6 times. With proper assessment of labor, taking into account the declining purchasing power of the national currency, which guarantees that the basic needs and demands are met, the return on investment in "labor" would have been noticeably lower. Thus, the coefficient of labor elasticity exceeding one unit may result from the growing productivity and the increasing workload (excessive employment—over one position per person) attributed to the employee's desire to compensate for the underestimated pay.

The negative value of the capital elasticity coefficient may be interpreted as an inexpediency of investing in fixed assets, but this idea would be false, since the lack of production capacities cannot be eliminated at the expense of other resources. What is more, giving up on mechanization and automation of production and economic activities in favor of "manual" labor also results in decreased productivity.

It is important to point out that the coefficient of labor elasticity in the regression equations of 83 regions is positive. Covering data from 2008 (earlier statistics required for the Cobb–Douglas function is not available), it is possible to calculate the production function for the Chechen Republic ($Y = 0.076*K^{1.107}*L^{0.012}$) according to Tables 3 and 4. The model goes as follows: $Y = 0.063*K^{1.248}*L^{-0.125}$. The negative sign confirms the change of the political course in the republic after 2008, which was associated with the beginning of the restoration of its territorial and economic complex after the completion of previously supported, primarily by allocating funds, counter-terrorist operations. This position of the Republic remains the same up to now. It means that high values of the capital elasticity coefficient may be well caused by the restoration of the worn-out fixed assets, including the non-technological ones that do not lead to the intensification of production.

Overall, the analysis of 83 coefficients of the production function models based on the input–output indicators, demonstrates the innovation dissimilarity between the given regions: in some places, "labor" has a special significance for the scale of production, while other territories prioritize "capital" and factors that are not included in the regression equation under consideration. For example, the Cobb–Douglas function for Moscow is as follows: $Y = 109.449{*}K^{0.032}{*}L^{0.702}$. The value of the constant in this case is far from typical, several times higher than in the regression equations obtained for other regions. This atypical value proves that such factors as scientific and technological progress have a bigger influence on the result in the meso-territories, rather than "labor" or "capital".

Due to the poor quality of the production function model based on the growth rate indicators, a detailed analysis of the calculated coefficients of the entire set of regression equations proves to be impractical. However, according to a brief analysis of relatively qualitative functional dependencies (17 models), the final indicator is influenced mostly by the discrete growth rates of "labor" (growth rates of labor costs—wages and social payments). As mentioned above, one of the most probable reasons is the underestimation of labor (low pay), typical for economies in transition, which has been gradually settling down since the beginning of the 2000s, but is yet to be completed. Another factor to consider is the dual influence of the employees' incomes on the GRP. On the one hand, they represent production costs, while on the other—a source of effective demand, creating an additional incentive for entrepreneurs. Undervalued labor in the innovation economy hinders transformation, because a person is not only a consumer of an innovative product but also a "generator" of innovative ideas. Consequently, low wages neglect the importance of the need for recognition and self-expression, thus, narrowing the entire life down to survival or satisfaction of basic needs. In such circumstances, workers seek to increase income by changing priorities: from quality to quantity, which results in excessive employment and distracts focus from a person's own knowledge, skills, and potential.

5. Discussion

5.1. Justification of the Hypothesis on the Possibility of Using the Production Function as a Tool for Assessment of the Innovation Climate in Regions

Using the quartile range, the population was divided into four quartiles (Q_1, Q_2, Q_3, Q_4). To test the stated hypotheses, it is appropriate to use the results of splitting the regions into quartiles with an emphasis on the extreme ones. Thus, the extreme quartiles Q_1 and Q_4 include the most and least favorable territories in terms of innovative conditions. It is obvious that a comparison of the results of two different methods for assessing the innovation climate (indicative analysis and regression analysis) should be carried out on elements of the general population that are significantly different from each other in order to obtain a clearer evidence base for substantiating the hypotheses put forward. If we take into account more similar territories included in the Q_2 and Q_3 quartiles, then the results will not be so unambiguous.

As a result of comparing the distribution data in the regions classified in quartiles Q_1 and Q_4, with the constant from the models of the production function based on the input–output rate, it is possible to conclude the following:

- In total, 21 regions were included in the Q_1 quartile, but only for 18 (excluding Tomsk Region, Perm Region, Chuvash Republic), do the obtained regression equations make economic sense. According to the analysis of these 18 models, nine regions showed an increasing return on production, the rest demonstrated a decreasing trend. In addition, for all the regions characterized by decreasing returns, the constant value exceeds one. If additional calculations were carried out, with the arbitrary values fitted in the constructed models, we would see that a 1% increase in "capital" or "labor" results in the final indicator growing by a percentage equal to the sum of the elasticity coefficients for "capital" and "labor". Changing the constant by the same rate gives a similar result.

- The Q_4 quartile includes 19 regions, while for 5 of them (Kemerovo Region, Orenburg Region, Rep. Dagestan, Rep. North Ossetia, Karachay–Cherkess Rep.) the revealed functional dependencies cannot be adequately interpreted. The analysis of the remaining 14 models shows that in eight regions an increasing return on production is present, while six other regions demonstrate the opposite result. Only in four regression equations is the constant higher than one. In ten models, the value of the elasticity coefficient for "labor" is higher than that for "capital".

The highlighted differences between the results of using two methods (interquartile range and production function based on the growth rate indicators) may attribute to the different time frameworks:

- 2009–2018—the first frame is impossible to expand due to the lack of data.
- 2000–2018—the second frame cannot be reduced because the quality of the regression equations will decrease. However, it is still apparent that the Q_1 quartile includes more regions with a constant (describing the influence of other factors, including scientific and technological progress) exceeding one, than the Q_4 quartile.

Initially, the choice of different periods for indicative analysis and regression analysis was due to the peculiarities of the second method. As mentioned above, the quality of the regression equation directly depends on the size of the data series—the larger it is, the better. In turn, it is impossible to conduct an indicative analysis for the same period (2000–2018), since there are no separate data on indicators in the context of Russian regions. But it is not possible to remove these regions from the general population, since the study is aimed at assessing the innovative conditions in all subjects of the federation.

However, in order to ensure the comparability of the results, it was decided to conduct a regression analysis, despite the deterioration in the quality of the models, for a period corresponding to the period of the indicative analysis.

In addition, production function models were built (shortened study period—2009–2018) for the subjects of the federation included in the extreme quartiles Q_1 and Q_4 (Table 6).

Despite the decrease in the quality of the models, the coefficient of determination and the F-criterion correspond to the norm. The number of models that cannot be economically justified among the regions included in the Q_1 and Q_4 quartiles increased to four and decreased to three, respectively.

For the vast majority of subjects of the federation included in the Q_1 quartile, increasing returns to scale of production are typical, while in the Q_4 quartile, it is decreasing. It is also worth noting that among the representatives of the Q_1 quartile, the number of subjects of the federation, where the coefficient of elasticity for "capital" is higher than the coefficient of elasticity for "labor", is more significant than among the representatives of the Q_4 quartile. In general, one can note the focus on the intensification of production in the subjects of the federation included in the Q_1 quartile due to the more significant impact on returns to scale of "capital" rather than "labor". At the same time, investments in fixed assets are associated with their renewal, including through innovation.

Table 6. The results of the calculation of the production function in a volumetric record for the subjects of the federation included in the extreme quartiles Q_1 and Q_4.

Regions	Production Function Model Based on Input–Output Indicators	Quality Parameters of Production Function Model		The Student's *t*-Test		
		R^2	F-Test	K	L	A
			Q_1			
Moscow	$Y = 24.947*K^{0.406}*L^{0.39}$	0.992	458	0.015	0.008	0.002
Rep. of Tatarstan	$Y = 0.139*K^{0.66}*L^{0.467}$	0.989	304	0.021	0.057	0.057
Khabarovsk Territory	$Y = 0.563*K^{0.82}*L^{0.172}$	0.972	120	0.237	0.811	0.536
St. Petersburg	$Y = 5.757*K^{0.532}*L^{0.342}$	0.984	210	0.078	0.283	0.044
Lipetsk Region	$Y = 0.147*K^{1.297}*L^{-0.248}$	0.988	278	0.000	0.315	0.018
Magadan Region	$Y = 0.01*K^{0.752}*L^{0.608}$	0.952	70	0.144	0.202	0.019
Kaluga Region	$Y = 0.412*K^{0.072}*L^{1.024}$	0.993	469	0.695	0.002	0.094
Tomsk Region	$Y = 1.242*K^{0.333}*L^{0.657}$	0.995	686	0.133	0.011	0.663
Yamalo–Nenets Autonomous Area	$Y = 0.001*K^{1.099}*L^{0.317}$	0.995	674	0.005	0.409	0.000
Belgorod Region	$Y = 0.656*K^{-0.163}*L^{1.279}$	0.989	320	0.499	0.003	0.506
Krasnoyarsk Territory	$Y = 0.363*K^{0.45}*L^{0.636}$	0.958	80	0.339	0.307	0.591
Nizhny Novgorod Region	$Y = 0.269*K^{0.54}*L^{0.541}$	0.995	671	0.021	0.030	0.015
Vologda Region	$Y = 0.005*K^{0.152}*L^{1.3}$	0.970	112	0.740	0.085	0.041
Rep. of Mordovia	$Y = 0.132*K^{0.442}*L^{0.706}$	0.997	1290	0.001	0.000	0.002
Voronezh Region	$Y = 0.048*K^{0.129}*L^{1.135}$	0.981	180	0.629	0.004	0.010
Tula Region	$Y = 0.036*K^{1.208}*L^{-0.016}$	0.995	747	0.001	0.950	0.000
Moscow Region	$Y = 0.033*K^{0.898}*L^{0.294}$	0.991	403	0.006	0.181	0.010
Chuvash Rep.	$Y = 0.674*K^{0.315}*L^{0.708}$	0.990	363	0.267	0.013	0.717
Rep. of Bashkortastan	$Y = 0.383*K^{-0.355}*L^{1.501}$	0.985	229	0.078	0.000	0.214
Perm Territory	$Y = 0.759*K^{0.184}*L^{0.866}$	0.963	91	0.746	0.180	0.817
Tyumen Region	$Y = 0.211*K^{0.656}*L^{0.423}$	0.978	158	0.047	0.263	0.190
			Q_4			
Kemerovo Region	$Y = 5.225*K^{0.097}*L^{0.803}$	0.829	17	0.845	0.216	0.467
Trans-Baikal Territory	$Y = 1.355*K^{0.295}*L^{0.66}$	0.974	132	0.487	0.061	0.883
Rep. of Altai	$Y = 1.513*K^{0.444}*L^{0.489}$	0.988	285	0.055	0.173	0.737
Orenburg Region	$Y = 0.476*K^{-0.11}*L^{1.241}$	0.983	208	0.744	0.024	0.506
Altai Territory	$Y = 0.0002*K^{1.386}*L^{0.216}$	0.986	241	0.026	0.417	0.048
Smolensk Region	$Y = 0.111*K^{0.103}*L^{1.103}$	0.986	247	0.733	0.010	0.014
Stavropol Territory	$Y = 0.376*K^{0.252}*L^{0.821}$	0.983	208	0.458	0.042	0.228
Rep. of Karelia	$Y = 0.004*K^{0.378}*L^{1.078}$	0.990	362	0.072	0.002	0.000
Kurgan Region	$Y = 0.332*K^{0.664}*L^{0.369}$	0.995	678	0.045	0.165	0.276
Nenets Autonomous Area	$Y = 41.143*K^{0.608}*L^{0.051}$	0.958	80	0.004	0.862	0.025
Kabardian–Balkar Rep.	$Y = 1.017*K^{0.789}*L^{0.167}$	0.990	334	0.077	0.579	0.991
Rep. of Daghestan	$Y = 9.519*K^{0.159}*L^{0.685}$	0.973	128	0.557	0.029	0.031
Rep. of Khakassia	$Y = 0.009*K^{0.806}*L^{0.556}$	0.992	444	0.014	0.048	0.000
Rep. of Adygeya	$Y = 0.254*K^{0.463}*L^{0.658}$	0.988	300	0.164	0.044	0.146
Rep. of Kalmykia	$Y = 0.005*K^{0.399}*L^{1.098}$	0.991	384	0.013	0.000	0.000
Rep. of North Ossetia	$Y = 198.817*K^{-0.599}*L^{1.199}$	0.959	82	0.128	0.002	0.019
Rep. of Tyva	$Y = 4.666*K^{0.546}*L^{0.293}$	0.983	204	0.087	0.505	0.323
Karachaev-Circassian Rep.	$Y = 24.887*K^{-0.113}*L^{0.851}$	0.981	180	0.595	0.001	0.006
Chechen Rep.	$Y = 0.076*K^{1.107}*L^{0.012}$	0.988	280	0.001	0.938	0.015
Rep. of Ingushetia	$Y = 7.744*K^{0.263}*L^{0.528}$	0.864	22	0.305	0.025	0.220

Models that do not make economic sense are highlighted in red; green—with increasing returns to scale; blue—in which the coefficient of elasticity for "capital" is higher than the coefficient of elasticity for "labor".

As you can see, the results of the calculations disproved the validity of Hypotheses 1 and 2, while confirming the expediency of Hypotheses 3 and 4. So, the production function can only be of an auxiliary nature, since it objectively reveals the impact on the production scale of production of only two factors—"labor" and "capital". The influence of other factors, which, unfortunately, cannot be named, reflects the value of the constant of this function. The complexity of disclosing the factors united by the constant of this regression equation is predetermined by the fact that production volumes are subject to various influences, including political, demographic, social and others. For example, a production function built for the Chechen Rep ($Y = 0.076^{*}K^{1.107}{}^{*}L^{0.012}$), objectively reflects the policy being implemented for additional funding of this subject of the federation (annual provision of nominal subsidies from the federal budget). Such support is the basis for the economic development of this Russian region, but the constant built for the Chechen Rep. in the Cobb–Douglas function model is close to zero. Therefore, it is impossible to talk about the significant impact of scientific and technological progress and innovations on the economy of this subject of the federation. In turn, according to the results of calculating the totality of visibility indicators, taking into account the subsequent ranking, the Chechen Rep. is included in the Q_4 quartile, which is characterized by less attractive innovative conditions, compared with other Russian regions.

According to the analysis results, the possibility of using the production function in a three-dimensional model to assess innovation climate is not rejected but is perceived solely as an auxiliary tool to identify the typical economic processes in the particular territory.

Thus, qualitative models of the production function based on the input–output and growth rate indicators confirm that the economy of regions depends on the key factors of production—"capital", "labor", and "technologies". However, in most meso-territories, it is "labor", not "capital", that has a greater impact on the production results, which indicates the low degree of its intensification. All together it reveals the lack of favorable conditions to stimulate innovation initiatives in most regions. Its content opens up opportunities for access to technologies, personnel, and equipment available in the external environment. This can become a tool for the redistribution of assets, entailing a smoothing of interregional differences. However, due to the peculiarities of the socio-economic development of the Russian regions, one of the barriers (Jonek-Kowalska 2021) to the spread of open innovations should include a high degree of differentiation in many respects. This fact predetermines a different approach to the common use of resource potential, developments, risk perception, and assessment of possible consequences for the parties (Yuana et al. 2021). Consequently, the position of the participants is unequal, which is a deterrent to building a model of open interaction in the field of innovation.

5.2. Discussion of the Prospects for Applying the Production Function Based on Input–Output and Growth Rate Indicators in Meso-Territories

The traditional Cobb–Douglas production function is a two-factor model, with "capital" and "labor" as predictors. Application of these types of economic resources or data in one way or another is typical for any model, including the resource-based or economic innovation model. The latter prioritize technologies that reduce the imbalance between declining resources and growing demands. In this regard, the application scope of this functional dependence is somewhat limited. On the one hand, the constant in the production function model based on the input–output indicators reflects the impact on the final indicator produced by omitted factors, such as innovation and technology. While on the other hand, it may be a sign of relatively neutral progress not related to the research and development but, say, responsible for the changes in consumer behavior—the transition to rational consumption and environmental conservation. The vagueness described above casts certain doubts on the acceptability of using the production function to assess the innovation climate in regions.

Nevertheless, if we turn to the values of the elasticity coefficients for "capital" and "labor", it is possible to define the type of economic growth established in the region. According to numerous scientific papers (Buravlev 2012; Kirilyuk 2013; Vaseyskaya and Glukhov 2019; Suvorov et al. 2020; Samoilova et al. 2021), if the elasticity coefficient for "capital" exceeds the similar coefficient for "labor", it marks the labor-saving (intensive) growth, and vice versa—the fund-saving (extensive) growth. The production function provides the grounds for identifying whether the intensification trend is inherent in the territorial and economic complex, which never excludes specific prospects for using the Cobb–Douglas function in research.

Another controversial point is the requirements for the data, which are used as dependent and independent variables. Initially, the Cobb–Douglas production function was tested in micro-regions, which allowed estimating the output and the resources spent using quantitative and physical indicators. The use of the production function in macroeconomics is associated not only with the complexity of selecting initial data, but also with the need to ensure the comparability of particular parameters. Thereby, as a generalized result of the economic activity performed by most actors making up part of the meso-territories, the GRP should be estimated in money because it is impossible to compare goods and services physically. The same problem is relevant for fixed assets, represented by buildings, premises, machinery, equipment, etc. When evaluating "labor", researchers (Kirilyuk 2013; Suvorov et al. 2020) agree that using the employment rate in calculations is appropriate. Despite this opinion, such an approach does not consider labor′s extensive and intensive components. The extensive component is reflected through multiple employment, while the intensive component is revealed through evaluating a worker′s qualifications. Concerning this fact, the cost assessment of labor proves to be more comprehensive since it includes both the extensive and intensive components.

Based on the specifics mentioned above, it is appropriate to conclude that using the entire set of variables in physical or value terms is preferable. Still, using the latter terms raises the question of whether to analyze comparable or current prices. An undoubted golden middle path is to opt for the first terms, using the second as an exception when official statistics are lacking.

6. Conclusions

According to the existing innovation climate, the study revealed a high heterogeneity of territories. Based on adjusted rate ratios, the following demotivating factors that hinder large-scale innovatization were identified: inadequate resource security, significant depreciation of the fixed assets, unstable investments, a decreasing number of people employed in research and development; weak involvement of state and public institutions in the transition to the innovation economy, which is confirmed by scarce reinvestment in economic expenditures; backward employment policies; lack of interest among the population, only sufficient to meet the basic needs.

The innovation stagnancy is reflected by the production function based on input–output and growth rate indicators, meaning that the predominant influence on the economic activity resulting in most regions is produced by the "labor" factor, in other words, an extensive component. Investing in "capital" does not affect returns to scale as in "labor". The study revealed disproportionality in the evaluation of these types of resources. Thus, the revaluation of fixed assets in the Russian Federation is carried out regularly, the costs of their renewal are adjusted, including considering global prices. At the same time, the cost of "labor" can be unchanged for years or even decrease. Many people during a crisis are willing to work for minimum wages and sometimes for free. In some years of the study period (2000–2018), the delay in paying wages in some sectors of the economy reached more than six months. There is a "chronic" underestimation of labor, and with expensive technologies and highly cheap labor, the introduction of innovations is futile. The cost of innovation will be many times higher than labor cost and will pay off in decades. In the context of economic and political instability, the revealed disproportionality in the evaluation of "capital", "technology," and "labor" is a dilemma for the entrepreneur: is it worth making long-term investments when you can earn income here and now?

The results of applying indicative analysis in combination with regression (production function) made it possible to formulate a key obstacle to the introduction of innovations, including open ones, into the Russian economy: there became a significant underestimation of labor. At the head of any innovations, including open ones, are people and their knowledge. With a significant underestimation, a person does not need self-development, since there are difficulties in satisfying primary (basic) needs. Low wages are not an incentive to develop new ideas; at the same time, minimal labor costs act as a constraint on innovative activity. Investments in innovation under such conditions become unpromising, since they significantly exceed labor costs. There is an extensive type of economic growth, and hence the lack of qualitative development. Here one could say that it is open innovations that will help break the "vicious circle": "labor—costs < innovations—costs". However, before carrying out a mutually beneficial exchange, something that will be profitable to exchange must be created. Again, there is a return to that "vicious circle". It should be noted that the underestimation of labor entails other negative consequences for the Russian economy in the context of the introduction of the concept of open innovation:

- "Brain drain"—leads to the impossibility of exchanging intellectual potential.
- Low interest of the end consumer in an innovative product, the cost of which at the first stages of sales can be significantly higher, since it is necessary to recoup the costs. With a high proportion of poor among the population, an expensive product will not be in demand.
- Investment unattractiveness of the Russian economy for innovative open companies.

The results obtained require a revision of the approach to labor assessment. At the state level, it is worth changing the procedure for calculating the minimum wage. At the moment, the minimum wage corresponds to the subsistence level in the Russian regions. It is an instrument of social protection—the labor component has been removed from it. This allows employers to manipulate the remuneration of employees in their interests; its reduction is in order to save on costs. At the same time, the employer refers to the state's determination that the minimum wage should only guarantee the minimum provision without taking into account the real costs of staff labor. Due to the low mobility of labor resources in the Russian regions, people agree to the working conditions put forward by the employer on the ground, to the detriment of their interests. At the same time, it is impossible to rely solely on increasing the mobility of the labor force, since this will lead to the desolation of the territories. This phenomenon is already observed in some Russian settlements. Thus, the equalization of wages in the Russian regions, based on accounting for the real labor costs of an employee, should become the basis of the economic strategy of the Russian Federation.

The authorities should participate more actively in transformations through investments in advanced technologies, benefits for innovatively active enterprises, and expenses for retraining personnel.

In turn, the traditional production function can be used as a supplementary tool for assessing the climate. Benchmark data also serves as an essential basis for the regression equation to be successfully developed. The best analysis course requires all indicators to have either a value or a physical expression due to the high volatility of federal money, with parallel fluctuations in the number of employees and material resources.

In general, a combination of heterogeneous analysis tools made it possible to detect a management trend typical for Russian regions, contributing to an increase in the objectivity of assessing innovative conditions at the meso level.

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