Econometric estimation of the Influence of Innovative environment on the sustainable development in the Volga Federal District

Tatiana Topoleva

Abstract. In conditions of the emerging economy of a new type, the process of innovation becomes a crucial factor that ensures competitiveness and sustainable development in a wide range of fields. The latter includes scientific and technological sectors as well as the spheres of management and social transformation. Sustainable economic development sets sharp growth as its objective alongside the innovative capacity building and its later realization, bringing local and national economies in line with the market standards, and the improvement of performance through the introduction of innovations.

The paper identifies and quantifies the most important factors of an innovative environment that affect sustainable development in the regions of the Volga Federal District [VFD]. We used the research methods of correlation and regression analysis. The established concept of the positive effects of innovative factors on the development of regions receives further confirmation and complementation from regression models for separate regions and the VFD in general compiled by us. Upon assessing the influence of innovations on the gross regional product in the regions of the VFD, we identified the introduction of advanced industrial technologies to the subjects of the VFD as the most influential factor. The research results can be implemented into the development of regional strategies for innovative development and its prognosis.

1 Introduction

The modern phase of economic modernization preserves the tendency for inertial development. It becomes especially prominent after an analysis of regional economies, their current state, and sustainability threats. In prospect, this issue may threaten the economic security of the Russian Federation. The scientific community actively promotes the idea of an innovative paradigm and discusses the efficiency of element saturation of regional innovative environments. Therefore, the assessment of the economic effects of innovative environments provided by this study proves to be of theoretical and methodological relevance. In the regional context, research on the strong and weak properties of the territory allows for a timely correction of programs and project management methods according to federal demands for innovative development.

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The role of innovations in economic development was first substantiated by Joseph Schumpeter. In the first half of the 20th century, he established a field of research on the relationship between economic dynamics and innovative activity rate. In the 80th, the European scientific association (GREMI) actively promoted the theory of innovative environments in organizational, cognitive, and analytical aspects. The mentioned group of researchers described the category of innovative environments as a local network of relationships that shape the external image and specific inner understanding of the territory aimed to create a sense of communion and stimulate innovative development of the territory through synergy and collective knowledge.

The definition and methodology of the innovative environment have received a range of varying interpretations. For example, I. A. Shalaev understands it as a “complex of socio-economic subsystems that provide the participants of the innovative process with an access to necessary resources” [7]. E. A. Voronina highlights the duality of the issue under review. According to the expert, an innovative environment is both “an economically organized space that provides a platform for the development of innovative resources” and “an integrated pool for accumulation and realization of the innovative potential in businesses” [8]. The studies by S. D. Firsova and E. S. Sviridova identify the innovative environment with mechanics formed by “a set of economic, managerial, financial, and social relationships” According to the researchers, the listed connections determine the conditions of business incubation and competitiveness rate in the sphere of innovative development in a region.

We suggest a complex understanding of the innovative environment based on combined scientific approaches and the development of theoretical theses. Considering institutional, infrastructural, and sociocultural aspects, we define the innovative environment as a set of phenomena and processes within a work framework of formal and informal institutions that establish legal, socio-economic, and political conditions for the environment formation. It includes the generation and distribution of innovations, efficient cooperation of regional stakeholders, and development of regional innovative potential. Furthermore, the innovative environment implies an establishment of innovative infrastructure, the development of unique competencies, tools, methods, and psychological features, and the overall formation of a business culture that ensures the functioning of innovative development mechanics.

In the Russian Federation, the regulation of innovative activity comes predominantly from the government. The state institutional systems form an innovative climate in the regions, regulate the innovative market, distribute resources to selected sectors, and stimulate innovative activity. The main goal of the regulatory activity is to establish sustainable development. The immense role of innovations in sustainable development has been proven by the findings of many Russian and foreign researchers. Among them are P. Drucker, D. K. Nort, J. Bernstein, D. Guellec, I. Randers, S. U. Glaziev, A. V. Loktev, I. A. Rudskaya, E. A. Ostapenko, and others [10-17].

The scientific results demonstrate that the interaction of innovative factors and economic systems results in the growth of the GDP rate of the country, or the GRP of a region compared to the costs of the innovation process. On the regional scale, sustainable development includes conditions for progress, economic balance, and a qualitative shift in the system. A sustainable economy is associated with a relatively stable increase in the main performance indicators that describe the capacity of a regional economic ecosystem [18]. The sustainability of a regional economy also stems from its capacity for self-development, adaptability in conditions of varying external factors, and high flexibility of its economic complex.

We conducted empirical research to identify the influence of the innovative environment on the sustainable development of the regional economy. They examined the relationship between innovative factors and the GRP rate of the VFD subjects. There is a broad range of studies on the issue that have formed a comprehensive theoretical and methodological base.
understanding of innovative factors Therefore, the present study aims to complement the established theoretical foundation with empirical data on the role of innovations in the economic processes in selected regions of the VFD and the district in general.

2 Materials and methods

The paper aims to identify and quantify the most influential factors of the innovative environment that affect the GRP of the VFD regions. Additionally, we aim to assess the direction and extent of this influence. The research objectives are (1) to select factorial variables and collect statistical data on the chosen parameters; (2) to conduct a correlation analysis; (3) to compile regression models; (4) to interpret the results in the context of the economic effects imposed by the researched factors. The studies on econometric modeling, especially correlation and regression analysis of innovation efficiency constituted the methodological foundation of the present research. The official statistical data on the socio-economical and innovative development of the VFD regions served as the informational foundation for the analysis. The study has reviewed the dynamics over the period from 2010 to 2019. The prolonged research period allows one to identify long-term tendencies. While in the short term, the growth boost is the prime objective, in the long term more importance is given to stability and sustainable dynamics.

To conduct the analysis, we used the econometric method and the Statistica 10 data processing software. The chosen tool provides a sufficient range of options that allows comfortable work with regression modeling. Statistically relevant results are automatically highlighted in the tables. Graphic interpretation of models is synchronized with the source material. This solution ensures a more efficient assessment of the research results. The correlation analysis aims to reveal the extent and direction of the correlation between factorial indicators and results. We assessed the relevance of correlation indexes based on the Chaddock scale. According to it, variables are functionally connected when the index is 1 and are independent when it is 0.

The regression analysis includes the allocation of the most influential factors for the GRP of the VFD regions. The variables that demonstrated little correlation between statistical characteristics of innovative development in the regions and the GRP rate were excluded from the sampling during preliminary selection. We aimed to receive statistically relevant regression models and valid results. The input data for analytical computations included:

- \( Y \) – the result variable, the GRP in every region of the VFD and the district in general, in million rubles.
- \( X_1 \) – the ratio of innovative products, works, and services from the total of obtained products, completed works, and services in the VFD regions, in %;
- \( X_2 \) – the ratio of organizations providing technical innovation to the total number of organizations in the VFD regions, in %;
- \( X_3 \) – advanced industrial technology used in the VFD regions, in units;
- \( X_4 \) – costs of innovative activity of organizations in the VFD regions, in million rubles.

3 Results

Table 1. The paired correlation indexes are organized by the respective VFD regions.
The Republic of Bashkortostan

Mari El Republic

The Republic of Mordovia

Republic of Tatarstan

Udmurt Republic

Chuvash Republic

Perm Region

Kirov Region

Nizhny Novgorod Region

Orenburg Region

Penza Region

Samara Region

Saratov Region

Ulyanovsk Region

VFD as a whole

Source: Compiled by the author based on the data provided by the Federal State Statistics Service (Science and Innovation section).
\( Y \) is the result variable; \( a \) is the regression indexes that describe the change in the result variable when affected by factorial variables; \( X \) is the factorial variables; \( n \) is the number of factors.

The results of the analysis are described in the summary table of the regression model parameters (Table 2).

The regression model of the VFD in general can be described as follows:

\[
Y = -4461824 + 65085 \cdot X_1 + 17380 \cdot X_2 + 149 \cdot X_3 + 13 \cdot X_4,
\]

(2)

To find the statistical relevance of the regression models, we analyzed the determinant index (R^2) and the probability indexes for regression value (p-values). The value can be found as a degree of compliance between the input data and the regression model. The determinant index reveals the influence caused by factorial variables on the result variable. To paraphrase, it described the dispersion of \( Y \) under the influence of \( X \) in linear regression. This indicator cannot exceed 1, and a model is considered relevant when its value exceeds 0.8. P-values higher than 0.05 indicate that a factorial variable causes a negligible effect on the result variable.

Cross-classification of the determinant indexes and value of the resulting regression models (Table 3) allows us to conclude that all the models under analysis are highly valuable. The only exception is the model describing factorial influence in the Perm Krai (R^2=0.745; p-value=0.094>0.05).

Table 2. The summary table of regression parameters is organized by the VFD regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>( X_1 )</th>
<th>( X_2 )</th>
<th>( X_3 )</th>
<th>( X_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Republic of Bashkortostan</td>
<td>94.656</td>
<td>3.87</td>
<td>1.53</td>
<td>1.25</td>
</tr>
<tr>
<td>Mari El Republic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Republic of Mordovia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Republic of Tatarstan</td>
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<td></td>
<td></td>
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<tr>
<td>Udmurt Republic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chuvash Republic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perm Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kirov Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nizhny Novgorod Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orenburg Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penza Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samara Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saratov Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulyanovsk Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFD as a whole</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Compiled by the author.

Table 3. The summary table for model value indicators in the VFD regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>( R^2 )</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perm Region</td>
<td>0.745</td>
<td>0.094</td>
</tr>
</tbody>
</table>

Source: Compiled by the author.
The Republic of Bashkortostan

Mari El Republic

The Republic of Mordovia

Republic of Tatarstan

Udmurt Republic

Chuvash Republic

Perm Region

Kirov Region

Nizhny Novgorod Region

Orenburg Region

Penza Region

Samara Region

Saratov Region

Ulyanovsk Region

VFD as a whole

Source: Compiled by the author.

Fig. 1. The regression model of effects caused by the factors of the innovative environment on the GRP of the Republic of Bashkortostan.

Source: Compiled by the author based on the analysis.

Fig. 2. The regression model of effects caused by the factors of the innovative environment on the GRP of Mari El Republic.
### Predicted vs. Observed Values

**Dependent variable:** \( Y \)

**Include condition:** Region: Republic of Mordovia

<table>
<thead>
<tr>
<th>Predicted Values</th>
<th>Observed Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 1 \times 10^5 )</td>
<td>( 0.95 ) Conf.Int.</td>
</tr>
<tr>
<td>( 2 \times 10^5 )</td>
<td></td>
</tr>
<tr>
<td>( 3 \times 10^5 )</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Compiled by the author based on the analysis.

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### Predicted vs. Observed Values

**Dependent variable:** \( Y \)

**Include condition:** Region: Republic of Tatarstan

<table>
<thead>
<tr>
<th>Predicted Values</th>
<th>Observed Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 8 \times 10^5 )</td>
<td>( 0.95 ) Conf.Int.</td>
</tr>
<tr>
<td>( 1 \times 10^6 )</td>
<td></td>
</tr>
<tr>
<td>( 2 \times 10^6 )</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Compiled by the author based on the analysis.

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### Predicted vs. Observed Values

**Dependent variable:** \( Y \)

**Include condition:** Region: Udmurt Republic

<table>
<thead>
<tr>
<th>Predicted Values</th>
<th>Observed Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 3 \times 10^5 )</td>
<td>( 0.95 ) Conf.Int.</td>
</tr>
<tr>
<td>( 4 \times 10^5 )</td>
<td></td>
</tr>
<tr>
<td>( 5 \times 10^5 )</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Compiled by the author based on the analysis.
Fig. 6. The regression model of effects caused by the factors of the innovative environment on the GRP of the Chuvash Republic. Source: Compiled by the author based on the analysis.

Fig. 7. The regression model of effects caused by the factors of the innovative environment on the GRP of the Perm Krai. Source: Compiled by the author based on the analysis.

Fig. 8. The regression model of effects caused by the factors of the innovative environment on the GRP of the Kirov region. Source: Compiled by the author based on the analysis.
Fig. 9. The regression model of effects caused by the factors of the innovative environment on the GRP of the Nizhny Novgorod region.

Source: Compiled by the author based on the analysis.

Fig. 10. The regression model of effects caused by the factors of the innovative environment on the GRP of the Orenburg region.

Source: Compiled by the author based on the analysis.

Fig. 11. The regression model of effects caused by the factors of the innovative environment on the GRP of the Penza region.

Source: Compiled by the author based on the analysis.
Fig. 12. The regression model of effects caused by the factors of the innovative environment on the GRP of the Samara region.
Source: Compiled by the author based on the analysis.

Fig. 13. The regression model of effects caused by the factors of the innovative environment on the GRP of the Saratov region.
Source: Compiled by the author based on the analysis.

Fig. 14. The regression model of effects caused by the factors of the innovative environment on the GRP of the Ulyanovsk region.
Source: Compiled by the author based on the analysis.

Fig. 15 demonstrates the influence of the innovative environment on the GRP of the VFD as a whole. The values do not fall under the confidence limits. However, they approximate them enough.
The resulting regression models for the VFD region as a whole and the regions of Ulyanovsk, Saratov, Samara, Orenburg, Nizhny Novgorod, Kirov, Perm, Chuvash Republic, Udmurt Republic of Tatarstan, Mari El Republic, Republic of Bashkortostan were analyzed. The Fisher criterion ($F_{\text{crit.}}$) allows us to compare average values of the parametric criteria to the critical value, which helps determine the critical area where the hypothesis diverges.

We found the following Fisher criterion values: $F_{\text{crit.}} = 5.62$, $t_{\text{crit.}} = 2.04$. The critical values allow us to conclude on the statistical accuracy of the regression model. The Fisher criterion ($F$) was calculated for each region and is given in Table 4.

Table 4 shows the input data for the parametric analysis of regression indexes and the prediction value for the VFD region. The summary table includes the predicted and observed values of the dependent variable $Y$ for each region. The predicted values for the VFD region as a whole are presented in Figure 15.

Source

Table 4: Predicted vs. Observed Values

<table>
<thead>
<tr>
<th>Region of VFD</th>
<th>Predicted Values</th>
<th>Observed Values</th>
<th>$F_{\text{crit.}}$</th>
<th>$t_{\text{crit.}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulyanovsk</td>
<td>8.76</td>
<td>5.244</td>
<td>37.015</td>
<td>5.425</td>
</tr>
<tr>
<td>Saratov</td>
<td>-4.29</td>
<td>5.258</td>
<td>45.322</td>
<td></td>
</tr>
<tr>
<td>Samara</td>
<td>-4.57</td>
<td>5.907</td>
<td>36.25</td>
<td></td>
</tr>
<tr>
<td>Orenburg</td>
<td>-2.89</td>
<td>4.18</td>
<td>54.53</td>
<td></td>
</tr>
<tr>
<td>Nizhny Novgorod</td>
<td>4.22</td>
<td>10.225</td>
<td>11.39</td>
<td></td>
</tr>
<tr>
<td>Kirov</td>
<td>3.62</td>
<td>3.62</td>
<td>10.225</td>
<td></td>
</tr>
<tr>
<td>Perm</td>
<td>-2.64</td>
<td>5.145</td>
<td>40.625</td>
<td></td>
</tr>
<tr>
<td>Chuvash</td>
<td>-2.64</td>
<td>5.145</td>
<td>40.625</td>
<td></td>
</tr>
<tr>
<td>Udmurt</td>
<td>4.97</td>
<td>2.796</td>
<td>21.708</td>
<td></td>
</tr>
<tr>
<td>Tatarstan</td>
<td>4.97</td>
<td>2.796</td>
<td>21.708</td>
<td></td>
</tr>
<tr>
<td>Republic</td>
<td>4.97</td>
<td>2.796</td>
<td>21.708</td>
<td></td>
</tr>
<tr>
<td>Mari El</td>
<td>3.668</td>
<td>3.078</td>
<td>50.529</td>
<td></td>
</tr>
<tr>
<td>Republic</td>
<td>3.668</td>
<td>3.078</td>
<td>50.529</td>
<td></td>
</tr>
<tr>
<td>Bashkortostan</td>
<td>3.668</td>
<td>3.078</td>
<td>50.529</td>
<td></td>
</tr>
</tbody>
</table>

Source: Compiled by the author based on the analysis of the VFD region as a whole and its regions.
the Perm krai model diverged from the trend, which further proves the statistical relevance of the obtained regression models. Therefore, the analysis of separate indexes and their value in all the regression models allows us to state that X3 is the most influential factor from the studied variety. Its positive effects manifested in 8 VFD regions and fluctuated from 78.2 to 798.5.

We provide the following interpretation of the described economic phenomenon. The strongest influence on the GRP of the VFD regions comes from the implementation of advanced industrial technologies. Therefore, every unit of technology contributes to the growth of the GRP rate. In the Orenburg region, an increase per one unit amounts to 798.5 million rubles, 385 million rubles in the Mari El Republic, 308.9 million rubles in the Republic of Tatarstan, 243 million rubles in the Kirov region, 243 million rubles in the Penza region, 185 million rubles in the Chuvash Republic, 127 million rubles in the Udmurt Republic, and 78.2 million rubles in the Saratov region. Over the VFD in general, the respective figure was 149 million rubles. Other factors did not demonstrate enough influence to be considered substantial for the VFD. The factor of costs on innovative activities in the VFD regions (X4) was relevant only for three regression models. For example, each excessive million rubles invested into innovative activity in the Ulyanovsk region increases the GRP by an average of 35.3 million rubles. In the Saratov region, this figure amounted to 18.1 million rubles, while for the VFD it is 13 million rubles.

4 Discussion

The regression models compiled by the authors ascertain earlier scientific findings on mostly positive effects caused by innovative environments [23-25]. Innovation factors influence regions differently depending on their types. At the same time, sustainable regional development is a complex category that is not limited solely by economic development. This fact calls for a deeper econometric analysis of the regional specificity of the VFD in the immediate future.

The regions of the VFD demonstrated varying development rates of the innovative environment in the context of human and business capital, technology business, acceleration of the innovation market, restoration of funds, and the concentration of local business communities. Insufficient funding for the innovation sector remains a pressing issue in a range of regions (the Udmurt Republic, the Kirov, Orenburg regions, etc.) due to poor budgetary provision and lack of business interest that would prompt entrepreneurs to engage in long-term innovative projects. Regional innovative environments and their quality experience pressure from hierarchical diffusion. The innovative process spreads in the largest agglomerations and regional centers while in more remote areas, the innovative activity is significantly lower. Another influential factor is a phenomenon of adjacent diffusion that manifests in a benefit of the maximal proximity to the sources of innovation compared to further locations [26].

The majority of objectives set by running regional programs of scientific and technological advancement are often ignored in practice. It is especially prominent in economically volatile regions of the VFD and serves to destabilize their economy even further.

5 Conclusion

The conducted research revealed the effect of the innovative environment on the sustainable development of the VFD regions. This conclusion received empirical evidence from the regression modeling results. The results complement the scientific apparatus with the compiled definition of the regional innovative environment. The latter explains the high
the VFD during the upcoming decade. Weaker regions, the effects of innovative factors will differ drastically within the regions of the VFD. The informational foundation for the choice and correction of managerial means is valuable for the strategic prognosis of the innovative advancement as they enhance the development institutions in the regions. Such a strategy will allow the regions to seamlessly integrate into global technologies, Industrial Tech, by local authorities. Orientation towards the most advanced technological solutions (digitalization, IoT, AR/VR, etc.) is another important aspect. Such an approach to the activation of innovative activity. This perspective has manifested selectively in three regression models (for the VFD as a whole, Saratov, and Krasnodar regions). Other sampled factors did not demonstrate any considerable influence. The research results have manifested selectively in three regression models (for the VFD as a whole, Saratov, and Krasnodar regions). Other sampled factors did not demonstrate any considerable influence.

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Hunt, S. (2007). Industrial technologies and their quantity has proven to cause the uboptimal state of innovative potential and governmental neglect of the VFD regions. The research output can be used by the ministry specialists, officials, and members of the research team as the basis for decision-making. The theoretical value of this study concerns the organization and management of the VFD. The research results have manifested selectively in three regression models (for the VFD as a whole, Saratov, and Krasnodar regions). Other sampled factors did not demonstrate any considerable influence. The research results have manifested selectively in three regression models (for the VFD as a whole, Saratov, and Krasnodar regions). Other sampled factors did not demonstrate any considerable influence.