INNOVATION FACTORS FOR HIGH AND MIDDLE-INCOME COUNTRIES IN THE INNOVATION MANAGEMENT CONTEXT

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ABSTRACT

Objectives: It is generally recognized that innovation is an important determinant of economic and social development in a globalized competitive economy. Under these conditions, the correct management of innovations at different levels and in various forms is one of the key conditions for success at all levels of economic activity. At the same time, various innovation factors exist and operate, and it is possible to single out the corresponding indicators that reflect the level of economic development of the country as a whole and its dynamics. However, to date, there has been a relatively limited amount of research on the characteristics that a country needs to have in order to innovate successfully. In more depth, questions remain about what the key innovation factors of a country are and how they affect its economic development level. Methods/Approach: The object of the study was the relationship between the key innovation factors and the economic development level. The aim of the study was to determine the possible relationship between the relevant innovation indicators and the level of development for high and medium-developed countries. Study approach: As a research methodology, the linear regression approach was used using the ordinary least squares model. Results: As a result, estimates of the relationship between the considered innovation indicators and the level of development were obtained. This makes it possible to single out priority areas and tools for improving innovation activity in order to achieve economic development. Conclusions: The obtained results can serve as a starting point for more detailed studies of various criteria for innovative activity and its implementation. The identified criteria can serve as a practical tool and be used in the process of management and measurement of innovation processes.

Keywords: innovation indicators, high and middle-income countries, innovation management, economic growth, country innovativeness

JEL classification: M31, M37, D12

Paper type: Research Paper.


INTRODUCTION

Today’s society is characterized by a context of multiple crises, not only from an economic point of view but also from an ecological one. The environmental issues, the worldwide energy crisis, the need for rational use
of natural resources, the search for new sources of energy, the development of new technologies that encourage savings, and the growing public awareness of environmentalism tend to connect even more economy to ecology (Shopova et al., 2023).

The interdependence between economic activity and the natural environment implies that firms and communities a necessary to implement environment-improving and sustainable technologies and business models (Ramazanov & Petrova, 2020). The starting point is that Earth is crowded, given that, according to the World Bank, the world population is nearly 8 billion people and continues to rise rapidly. Humanity itself, through the economy, has created a huge environmental crisis on several fronts, such as the changing climate, the availability of water, the oceans’ chemistry, and the habitats of certain animal species.

All these environmental threats are dangerously influencing the key processes upon which life depends, such as the cycles of carbon, and have unpredictable and disastrous consequences in the long term (Helming et. al., 2008; Kates et. al., 2005; Strange & Bayley, 2008). A conclusion can be drawn, that material gains are not sufficient to measure and preserve human well-being. Globalization processes are increasing rapidly economic interdependence of countries leading to a twofold consequence: first, customers have a large multitude of choices in the market; second, firms are exposed to increased competition pressures (Schumpeter, 1942; Ricupero, 2017). On the other hand, countries are also interdependent in the creation of innovations, a paradigm of open innovation (Chesbrough, 2003; Odinokova et al., 2018; Kurmanov et al., 2019).

Based on these premises, the idea of innovation becomes more important with the aim of making a difference in facing developmental challenges. The expression innovation refers, in general, to the implementation of new ideas leading a firm to increase its value, and with a close relationship between management control methods and innovation (Henri & Wouters, 2020). On the country level, it is important to bring out key innovation factors pointing to the corresponding targets of the innovation policy.

**LITERATURE REVIEW**

It has been scientifically proven (Drašković et. al., 2020) that in the knowledge economy, innovation is a key resource, and sound management of innovative potential is a key competitive advantage. As rightly pointed out (Sinclair-Desgagné, 2022), despite the successes, managing innovation and measuring the level of innovation remains a challenge for both research scientists and management practitioners. At the same time, the introduction and development of innovations in various forms and levels require appropriate approaches and techniques of innovation management, which reflects a significant number of scientific publications. For example, the purpose of the study (Firsova et. al., 2020) was to search for relevant indicators and tools for modeling and managing an innovation system, taking into account related factors and socioeconomic needs. The relevance of innovation management issues is substantiated in the publication (Berdar & Yevtushesvksa, 2020). Among them is the analysis of the main indicators of innovative activity. Research and analysis of key performance indicators of advanced innovations are also described in (Seiler et. al., 2022).
A significant number of articles are devoted to innovation management on the examples of countries with different levels of development. Thus, innovation management in the examples of European and US markets is described in the study (Bielialov, 2022). The possibilities of managing innovative processes and their analysis in companies (in the example of Poland) are presented in the publication (Dziura & Rojek, 2021).

Modern theoretical and practical achievements in the field of innovation management are presented, and the possibilities of managing innovation processes in business are emphasized. The transition to management with a focus on eco-innovation in Romania is explored in detail in (Crișan et. al., 2021). The impact of innovation on economic performance and business performance in Mexico is described in the article (Valdez-Juárez et. al., 2022). The study (Ruiter et. al., 2021) using the example of the Netherlands, examines how various forms of strategic control support and enable innovation in the context of the principles of a circular economy. The article (Sadyrova et. al., 2021) discusses the problems and factors of innovation process management in Kazakhstan. It is especially noted that the innovative path for countries with an average level of development is becoming an urgent problem.

The study (Gazi et. al., 2022) on the North Cyprus example presents estimates of the impact of management on the effectiveness of innovation, organizational culture, and overall business performance to achieve sustainable balanced scorecards. The main result of the article (Bielińska-Dusza & Hamerska, 2021) is the identification of the innovation index and, consequently, the position of countries in the European Innovation Ranking. This article discusses issues related to the measurement of innovation, which is necessary for effective management, as well as the study of innovation in individual countries. Particular attention is paid to the methodological aspects of building the European Innovation Ranking (EIS). Research (Nepelski & Roy, 2021) proves that innovation management requires new data, indicators, and tools. At the same time, the digital transformation of management affects the competitiveness, sustainability, and viability of the entire innovation system (Satalkina & Steiner, 2020). The literature (Jong, 2021) confirms that measuring innovation is a difficult but necessary management task to improve business performance.

Key Performance Indicators (KPIs) can be used to measure and monitor innovation. The article (Lo & Kam, 2021) is also devoted to the issues of comprehensive measurement of the effectiveness of innovations. It substantiates the need to identify key indicators to measure the effectiveness of innovations. The authors (Aman & Seuring, 2022) emphasize the need to manage key performance indicators (KPIs) considering all three aspects of sustainability: social, environmental, and economical. At the same time, a certain procedure, and special indicators for making management decisions, and an information base for the digitalization of calculations are needed (Bril et. al., 2021). Particularly noteworthy is an interesting and fairly in-depth study (Ahtsham et. al., 2021). It examines the role of innovation in achieving high macroeconomic performance. Five main indices are used for the analysis: the Energy Index, Financial Index, Human Index, Fiscal Index, and Environmental Index of Macroeconomic Vital Indicators developed for the G7 countries. This study suggests ways to accelerate economic growth without damaging the environment in the G7 countries.
Main types of innovation exist: first, a product innovation, which is the introduction of a product or service that is new or significantly improved with respect to its previous features; second, a process innovation, which is the application of a new or significantly improved production and/or method; third, a marketing innovation, which is the implementation of a new marketing strategy characterized by significant changes in pricing, promotion, placement, and/or packaging; and four, an organizational innovation, which is referred to new practices and/or relations at the organizational level (Schumpeter, 1942; Fagerberg, 2004; Rogers, 2005; Greenhalgh & Rogers, 2006; Tiwari, 2008; West & Farr, 2009; Utterback, 2014; Pleschak & Sabisch, 2016).

Even though innovation has been the most important driving force of modern economic development over the past decades, currently generalizing the theoretical, and conceptual foundations for understanding and describing innovative development in terms of its mechanisms, factors, and their interdependencies, the impact on various aspects of the economic and social life of society, are only in the process of formation and comprehension (Schultz, 2008).

Empirical evidence shows that a positive association between innovation and economic growth exists and that it is possible to achieve both economic and environmental goals. Obviously, a high level of innovation in the process of economic growth makes it possible to resist environmental damage, form knowledge-oriented production and the economy, and as a result, ensure the growth of social welfare and living standards. Therefore, innovations are actually indicators of the socioeconomic level, the prospects for its increase, and the capabilities of subjects of economic and economic activity (both individuals and legal entities) (Fagerberg et. al., 2009).

Recently, a few general theoretical and narrower studies have appeared on innovations, their various aspects, and indicators. Among them is the article (Onea, 2020) where the influence of individual indicators of innovation activity on the overall innovation process is determined. For this, a quantitative methodological approach was applied using SPSS. A strong correlation was found between investment and the innovation process. In the paper (Niyungeko, 2022) studies of the relationship between innovation activity and simplification of business regulation in various countries are presented.

The publication (Shahin & Mahdian, 2020) is dedicated to ranking indicators of innovation in the development of new products using the fuzzy TOPSIS method. The indicators considered include the size of innovation, organizational factors, individual and environmental factors, as well as technological, marketing, support, intra-organizational, commercialization, product development team, and methods of innovation.

Of interest is the article (Iizuka & Hollanders, 2020) where is confirmed that innovation is an important driving force of economic growth. Many low- and middle-income countries use innovation metrics to monitor the effectiveness of innovation and evaluate the impact of innovation policies. At the same time, innovation indicators should be adapted to various socio-economic conditions and structures, considering the diversity of national innovation systems and related factors.

Research (Rainatto & Silva, 2021) shows that it is possible to determine the effectiveness of innovations based on patent production, investment in R&D, and the number of scientific publications. At the same time,
the article (Baboshkin et. al., 2021) argues that there are different methods and approaches to grouping countries according to the behavior of their innovation indicators. Marginal analysis and machine learning methods (mean shift, agglomerative clustering, and random forest methods) can be used to identify relationships between innovation indicators. Other methods for analyzing innovation are discussed in (Gokhan et. al., 2021). It is emphasized that numerous global databases contain many indicators that measure and compare the effectiveness of countries’ innovation policies.

However, there are many problems associated with the definition, classification, and systematic analysis of these indicators to measure, monitor and improve performance. The necessity of specific indicators in each specific case is substantiated. A review of publications on the application of TOPSIS, VIKOR, PROMETHEE I-II, ARAS, COPRAS, MULTIMOORA, ELECTRE, SAW, and MAUT methods for the problem of innovation activity analysis is given. The possibilities of cluster analysis and MCDM methods for this task are also substantiated.

At the end of a brief review of the literature, we mention the publication (Popa, 2020). It showed that innovation, research, and development are factors that have a direct impact on economic growth, which makes it possible to establish effective development strategies for various national economies.

Concluding the review of the literature, we consider it necessary to note that the issues of identifying, measuring, and analyzing the factors of innovative development, in general, continue to be an important research problem to date and will remain relevant in the future. However, the attention of our study is directed to a generalized search and analysis of such indicators specifically for low and medium-developed countries, and in general, which is especially important from the point of view of developing common approaches to their development. So, the aim of the research is to determine the strength and direction of the influence of key innovative indicators on the long-term prospects for the economic development of countries with high- and middle-income levels.

THEORETICAL FRAMEWORK

First, let’s shortly consider Economic Growth. The positive association between economic growth and innovation is often described by recourse to the optimistic scenario of classical, so-called "old" understanding of economic growth, an approach that considers and interprets economic growth as a general increase in the production of goods and the provision of services in terms of value. At the same time, economic growth is correlated with an increase in gross domestic product per capita. So, the mentioned theory among the sources of productivity growth considers (as fundamental) precisely the increase in the size of capital, as well as exogenous factors, which are defined as technological advances. Therefore, in terms of development in the future, higher rates of technological progress cause and ensure an increase in the level of GDP, (Solow, 2006; Solow, 2007).

Next, let’s more detail consider Innovation Indicators. The presence of a deep mutual influence on the economic level of development, the dynamics of economic growth itself, and innovation are obvious.
However, the interaction and interrelationships between them are quite complex and non-linear, it is obvious that there are many multidirectional factors of different strengths of influence, efficiency, and duration. Therefore, the issue of identifying the key factors of such influence, and the direction of their impact on the development level of the economy, becomes relevant. The consideration of innovations as a multidimensional phenomenon presupposes a comprehensive consideration of their production-economic, socio-political, and natural-ecological effects. Accordingly, any complex choice of innovative characteristics requires consideration (representation), in addition to economic and technical indicators, as well as social, public, and humanitarian aspects (Stevens & Burley, 2007; Denti, 2013).

By adopting these criteria, authors propose and highlight for further consideration a set of key important national-level innovation indicators.

*Total trademarks* and *Patents.* A bulk of evidence shows that stronger intellectual property protection systems do not lead to economic growth. Specifically, these systems are created in the name of progress and are supposed to contribute to spreading knowledge, but in reality, they are found to limit the diffusion of innovations. Moreover, they are expensive and not enduring. Consequently, they are found to negatively affect prosperity (Alston & Venner, 2000; Hughes, Moore, & Snyder, 2002; Lo, 2011; Boldrin & Levine, 2012; Lemly, 2014).

This is the reason why our hypotheses on trademarks and patents are the next:

*Hypothesis 1:* There is a negative relationship between trademarks and economic development level;

*Hypothesis 2:* There is a negative relationship between patents and economic development level.

*High-technology exports.* The available literature stresses that specialization in technologically intensive activities has a key role in economic growth, given that it makes it possible to take technological opportunities (Nelson & Phelps, 2016), and improve product quality (Fagerberg, 2004). As consequence, the share of high-technology exports represents a fundamental indicator of innovation to use as a benchmark of a country’s innovation performance, because it affects the differences in GDP. More deeply, the export of technology-intensive products and services is positively related to GDP and drives the growth of the economy.

Exports of high-tech products and services can be viewed as a key innovation output indicator, therefore we propose to consider the following hypothesis:

*Hypothesis 3:* There is a positive relationship between high-technology export and economic development level.

*Journal articles.* Literary sources quite often state that the views that advance in research translate to higher rates of economic growth because the obtained results are implemented through effective programs (Trajtenberg, 2002; Mohnen & Roller, 2011). The same opinion exists at the level of public consciousness, especially in scientific and educational circles. However, it does not necessarily mean that knowledge from institutes and universities in the form of scientific publications is directly applied to innovations. Indeed, the concept of open science is currently spreading as a new form of knowledge, that is rapid, complete, and played by informal norms and inventions (Dasgupta & David, 2004; Aghion et al., 2008).
Therefore, for scientific publications in journals, we propose to consider such a hypothesis:

**Hypothesis 4:** The publication of journal articles has no direct impact on the economic development level.

**Linkages.** There is a close relationship between the concept of knowledge diffusion and economic growth. Specifically, the sharing of information, coming from not only internal sources but also external ones, allows for the implementation of rapid decommodification and transmission procedures, saving costs and time, and improving innovation processes.

This is the reason why our hypothesis on linkages is:

**Hypothesis 5:** Strong linkages are positively correlated with economic development level.

**Training activity.** Many literary sources confirm that the level of general and vocational education and the level of economic development, as such, in general, are closely interconnected, although such a relationship is not directly proportional, but has a more complex structure and internal content. The total expenditure on education (both from state budgets and from private sources) is an investment that undoubtedly contributes to economic growth and development. After all, in this way, the production forces are improved, qualification, and productivity increase, which gives an undoubted economic effect. On an intuitive level, it is obvious that well-trained workers tend to be more efficient and add more value than workers with poorer training (Acemoglu et al., 2003; Benhabib & Spiegel, 2004; Lucas, 2008; Krueger & Lindahl, 2011; Mankiw et al., 2012; Sapir, 2013; Hongfu, 2014; Nelson & Phelps, 2016).

Therefore, we should include in our hypotheses the assumption of the influence of training and educational activity:

**Hypothesis 6:** Higher training activity increases economic development level.

**Research and Development (R&D) expenditure.** Research is a fundamental driver of economic growth, given that investments in innovation improve technological development. Expenditures, and more specifically R&D spending, reflect the regional scientific, technological, and economic strength: richer and faster growing States increase their expenditure (Hongfu, 2014). At the same time, evidence demonstrates that several undeveloped markets are characterized by economic growth, thanks to direct or indirect capital investments (Aghion et al., 2009).

In line with this, finally, we propose to consider the hypothesis regarding research and development activities, and our assumption about R&D spending is as follows:

**Hypothesis 7:** Higher R&D expenditure is associated with economic development level.

**MATERIALS AND METHODS**

Thus, we need to consider and compare the level of development of the country and the indicators chosen to establish the presence of dependencies that may affect innovative growth.

**Data sources and samples.** To do this, we will consider 50 countries, including both high- and middle-income countries (https://www.worldeconomics.com/Regions/High-Income-Countries/). For the distribution of countries into the two groups mentioned, we will use data from the World Bank Atlas. At the same time,
we will classify as high-income countries those that have a gross national income (GNI) per capita of about 14,000 US dollars or more; as countries with an upper-middle income, we will include those countries for which this indicator lies in the range of 4,000 up to 14,000 dollars. It should be noted that this indicator is quite conservative (slowly dynamic over several years), and therefore the indicated division remains quite adequate in the short and medium term. Of course, we do not consider here lower-middle income and low-income countries (developing countries), for which the study of innovation activity can reveal much more other factors of influence.

In our study, the group (32) of high-developed countries includes the following: Australia, Austria, Belgium, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Israel, Italy, Japan, Korea, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Panama, Poland, Portugal, Romania, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States, Uruguay.

In turn, the group of less developed countries (18) considered by us included: Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Czech Republic, Ecuador, Latvia, Malaysia, Mexico, Russia, Serbia, Slovak Republic, South Africa, Spain, Turkey. The initial numerical information for each considered indicator (potential indicator) was obtained on the basis of a synthesis of data for a period of five years on the web resources of UNESCO and the World Bank.

Variables definition and estimation procedure. When performing calculations, we used the well-known, classical statistical approach based on multiple linear regression using the least squares method. The task was, as already described above, to statistically investigate the possible relationships between the considered innovative indicators (their changes) and the dynamics of development for the corresponding countries. With this formulation of the problem, the indicator of economic development level acts as a dependent variable. And the independent variables described (chosen by us) above reflect the corresponding changes in individual features and the possibility of considering which innovative indicators we want to establish (confirm or refute).

Initial GDP values are considered in US dollars. The level of economic development is obtained by dividing the GDP by the population of the corresponding country. And the GDP itself consists of the gross value added produced by all residents (producers of goods and services), as well as the corresponding taxes on them.

At the same time, subsidies that are not included in the cost of goods and services are excluded from GDP. Thus, in our calculations, as independent variables, we will use the previously selected parameters (possible indicators), which we will measure, as presented below:

– **total trademarks** count the number of relevant applications registered in the systems of national intellectual property regulators in order to register a trademark, which serves to designate certain goods, products, and services produced or provided by certain legal entities (enterprises, organizations, other subjects of business, economic, as well as social activity);

– **total patents** count the total number of patent applications for copyrights filed (to the relevant regulatory authorities) for the considered period of time (of a wide variety of nature - for goods, products, technologies, processes, technical solutions, etc.).
– **high-technology exports** count a volume of products characterized by a high level of R&D intensity, and are expressed as a percentage of total exports;

– **journal articles count** the number of scientific, technical, research, and engineering publications, which include papers dealing with fundamental and exact sciences, sciences related to engineering and technology, medicine and health sciences, socio-economic sciences;

– **linkages** count the number of communication contacts of various levels and volumes for the exchange of relevant information, modern knowledge, and advanced technologies, connecting various subjects of economic, production, and industrial activity with other economic actors, in particular, scientific, academic and university researchers, government institutions, political and public spheres, various participants in the markets for goods and services.

These ratings are expressed in percentage, in the range of 10% (low linkages) to 100% (high linkages);

– **training activity** counts the number of and represents the percentage of firms that offer different levels of duration, focus, and content of learning, training, and improving professional skills educational training programs and procedures (continuous learning throughout life and professional development) for their employees;

– **R&D expenditures** are expenditures of both public and private nature for research and development, and they are measured as a share of GDP.

**RESULTS**

*Descriptive statistics and correlations.* Before constructing the regression equation directly, it is first necessary to consider the main characteristics of the input data used. Accordingly, the data relating to descriptive statistics are presented in Table 1, and the correlation coefficients are in Table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita</td>
<td>31262.0</td>
<td>21935.2</td>
<td>4514.94</td>
<td>116664.00</td>
<td>24577.4</td>
</tr>
<tr>
<td>Total trademarks</td>
<td>100.92</td>
<td>15.00</td>
<td>1.13</td>
<td>1270.00</td>
<td>233.62</td>
</tr>
<tr>
<td>Total patents</td>
<td>152.85</td>
<td>15.30</td>
<td>1.02</td>
<td>993.00</td>
<td>242.09</td>
</tr>
<tr>
<td>High-tech exports</td>
<td>0.15</td>
<td>0.13</td>
<td>0.00</td>
<td>0.47</td>
<td>0.11</td>
</tr>
<tr>
<td>Journal articles</td>
<td>87.19</td>
<td>13.55</td>
<td>1.10</td>
<td>727.00</td>
<td>164.93</td>
</tr>
<tr>
<td>Linkages</td>
<td>0.51</td>
<td>0.50</td>
<td>0.14</td>
<td>0.93</td>
<td>0.19</td>
</tr>
<tr>
<td>Training activity</td>
<td>0.45</td>
<td>0.50</td>
<td>0.10</td>
<td>0.91</td>
<td>0.18</td>
</tr>
<tr>
<td>R&amp;D expenditure</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
<td>0.04</td>
<td>0.01</td>
</tr>
</tbody>
</table>

*Source: Own author's calculations*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total trademarks</td>
<td>0.14</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total patents</td>
<td>-0.23</td>
<td>0.08</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-tech exports</td>
<td>-0.17</td>
<td>0.25</td>
<td>-0.14</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal articles</td>
<td>-0.25</td>
<td>0.22</td>
<td>-0.03</td>
<td>-0.11</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linkages</td>
<td>0.31</td>
<td>-0.02</td>
<td>-0.21</td>
<td>-0.17</td>
<td>-0.02</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training activity</td>
<td>0.18</td>
<td>0.29</td>
<td>0.15</td>
<td>0.18</td>
<td>-0.05</td>
<td>-0.02</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>R&amp;D expenditure</td>
<td>0.49</td>
<td>0.05</td>
<td>-0.12</td>
<td>0.11</td>
<td>-0.25</td>
<td>0.14</td>
<td>0.08</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Source: Own author's calculations*
The preliminary analysis based on the correlation matrix presented in Table 2 shows that the selected innovation indicators are relatively independent variables, with mostly weak and in some cases moderate correlations with each other. We can see that R&D expenditure and linkages have a moderate positive correlation with per capita GDP while training activity, high-tech exports, and trademarks are relatively weakly correlated. The patents and journal articles point to the weak to medium negative correlation with our dependent variable.

Hypotheses test. In our case, the regression equation (using the least squares method) used 250 observations. As described above, considering 50 countries with corresponding indicators (Total Trademarks, Total Patents, High-Technology Exports, Journal Articles, Linkages, Training, and R&D expenditure were the independent variables) over a five-year period. And economic development level (per capita GDP) was the dependent variable. The results of testing each of the previously stated hypotheses are shown below in Table 3.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>P&lt;</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-11809.6</td>
<td>0.01</td>
<td>5453.12</td>
</tr>
<tr>
<td>Total trademarks</td>
<td>-25.03</td>
<td>0.001</td>
<td>3.32</td>
</tr>
<tr>
<td>Total patents</td>
<td>-12.64</td>
<td>0.001</td>
<td>4.24</td>
</tr>
<tr>
<td>High-tech exports</td>
<td>38332.7</td>
<td>0.01</td>
<td>14885.8</td>
</tr>
<tr>
<td>Journal articles</td>
<td>-9.61</td>
<td>0.05</td>
<td>6.60</td>
</tr>
<tr>
<td>Linkages</td>
<td>33049.7</td>
<td>0.001</td>
<td>5779.73</td>
</tr>
<tr>
<td>Training activity</td>
<td>27756.7</td>
<td>0.01</td>
<td>10879.7</td>
</tr>
<tr>
<td>R&amp;D expenditure</td>
<td>941797</td>
<td>0.001</td>
<td>88157.7</td>
</tr>
</tbody>
</table>

Source: Own author’s calculations

It turned out that six of the seven parameters proposed as indicators of innovation have a corresponding effect. At the same time, the influence of one of the parameters was not confirmed. Let us consider these results in more detail. It should be noted that in this calculation, R-squared is 0.42, and Log-likelihood is -2813.70. thus, and for our hypotheses, the final results have been obtained. Note that the indicated value of the R-square in practice means that the proposed (as indicators of economic growth) innovation parameters predict about 44% of its dispersion. Considering each hypothesis separately, the following can be noted.

Hypothesis 1 is confirmed (accepted). Thus, a negative and statistically significant correlation between the total number of trademarks and development is confirmed (P<0.001).

Hypothesis 2 is confirmed (accepted). There is also a statistically significant strong (P<0.001) negative relationship between the total number of patents and development.

Hypothesis 3 is confirmed (accepted). At the same time, the relationship between development with high-tech exports turned out to be positive, but with little significance (P<0.01).

Hypothesis 5 is confirmed (accepted). A statistically strong (P<0.001) positive relationship between linkages and development has been established.

Hypothesis 6 is confirmed (accepted). It also turned out that the impact of various training and educational efforts, events, and activities on development is weakly, marginally statistically significant (P<0.01), and at the same time is positive.

Hypothesis 7 is confirmed (accepted). Specifically, the correlation between R&D expenditure and
development is positive and also statistically strong (P<0.001). Among the proposed hypotheses and the corresponding potential signs (criteria for monitoring the level of development and innovation), one was revealed that did not find statistically calculated confirmation.

Hypothesis 4 is not confirmed (rejected). It turned out that the number of scientific publications (P<0.05) does not practically show a connection with the development and is not statistically significant.

**DISCUSSION**

Let us discuss in more detail the obtained results of our research, and the possibility of considering the selected parameters as innovative indicators. Before proceeding to a detailed exposition and discussion of our results, it is expedient to dwell on the most recent publications, which in one way or another elucidate the questions we are considering and related questions.

Of particular interest in this regard are publications on various aspects of innovation. First, we note the monograph (Silva et. al., 2022) which outlines the evolution of innovative indicators throughout the entire period of their research. The publication (Nappi & Kelly, 2021) confirms that innovation processes are crucial for economic growth. The paper (Iacovoiu & Stancu, 2017) highlights the relationship between innovation performance and economic development. Based on worldwide indicators for 2013 they found a significant correlation between the gross domestic product (dependent variable) and the WEF innovation performance indicator (INOV, independent variable). Another study by the same author (Iacovoiu, 2016) also confirmed the relationship between innovation efficiency and economic development.

The research (Terzić, 2020) indicates that the relationship between economic well-being and innovation activity remains an important area of research. There are several methodologies for studying them. The authors used the SPSS statistical software package and showed that economic well-being in European countries is largely associated with their innovative activity. According to (Samoilova & Rodionov, 2022), assessing the innovation climate is a difficult task. The necessity of using statistical analysis methods for this is emphasized. In (Melón et. al., 2022), for the analysis of innovations, a multi-criteria decision analysis method is proposed.

The article (Nappi & Kelly, 2022) emphasizes that performance indicators are crucial for measuring the innovation process. An analysis of the literature on the composition of these indicators is given, among which implicit knowledge stands out, which formalization and subsequent measurement becomes a necessary task when considering innovations. Publication (Kuzma et. al., 2021) takes a detailed look at indicators and levels of innovation based on a review of 125 articles. There is a predominance of environmental indicators and the absence of indicators for the mesolevel. Research (Volchik et. al., 2022) confirms that the analysis of innovation systems is a complex task that needs to be addressed in a comprehensive manner. For formalized modeling, the authors propose such indicators of innovation as the share of innovative goods, works, services in the total volume, and the share of costs for innovative activities. There is also a relationship between innovativeness indicators and the number of patent applications and granted patents.

The aim of the study (Sossa et. al., 2022) was to identify variables within the framework of the innovation
system concept, as well as the methodology for their diagnosis. It is argued that at present there are no generally accepted universal approaches to their measurement in the context of the relationship between innovation and development at the regional level. A detailed study (Hintringer et. al., 2021) focuses on quantifying innovation and determining its impact on a country’s economic success. Factors considered include government intervention, knowledge flows, cultural and social preconditions, and openness to change. Linear regression and the least squares method were used to identify relationships. Two of the selected quantitative innovation factors have a statistically significant impact on economic growth in this model. The number of researchers per million people and the number of patents granted by residents are identified as benchmarks for innovation.

Article (Ribeiro et. al., 2022) justifies the use of trademark and patent data as indicators of innovation. Their high correlation coefficient is found with patents and trademarks at different scales: firm, sector, country, and global scale. However, for developing countries, trademark data better reflects the degree of innovation. In (Naveed & Shabbir, 2022), the indicators of innovation activity and the corresponding indicators are also considered. The publication (Svensson, 2022) on the example of Sweden confirms our assumptions that the indicators of patent activity reflect technological innovations and are closely interrelated with them. In article (Caruso et. al., 2020) is proposed an eco-innovation model that includes five internal factors that reflect business opportunities and three external factors that study the effect of eco-innovation activities.

Article (Bielińska-Dusza & Hamerska, 2021) discusses the Composite Innovation Index, which determines the position of countries in the European Innovation Ranking (EIS). A linear ordering method is used to reduce the number of indicators from 27 to 22, but the number remains quite large. The study (Apostu et. al., 2022) examines the impact of education (especially higher education), entrepreneurial skills, and innovative capacity on economic growth. A positive effect of higher education on economic growth was found, however, two other variables (entrepreneurship and innovation) were found to be insignificant in this study, for this time period and data. Research (Khyareh & Rostami, 2022) shows that in emerging economies, innovation activity and macroeconomic factors are strongly interrelated. There is a strong positive impact of innovation activity on competitiveness.

Returning to our results, we note first of all that, at first glance, unexpected results (negative influence) are obtained for the first two hypotheses. It turns out that an increase in the number of registered patents and present (come on the market) trademarks have a very negative impact on the innovation component of economic growth. However, this can be explained in such a (perhaps paradoxically) way that a developed and effective system for the protection and enforcement of intellectual property rights, while having unconditional positive aspects of influencing the economy, at the same time often hinders the introduction and development of competing innovations.

With regard to Hypotheses 5 and 7, we find that higher levels of linkages, in the form of sharing and cooperation, and R&D expenditures, ensure economic growth. The results of calculations for hypotheses 3 and 6 show that such components as high-technology exports and training activities have a positive but minimal effect on economic growth. And, finally, the assumption that high scientific and publication activity is
associated with economic growth was not confirmed. By the way, examples and confirmations of this in the dynamics of the economic development of certain countries at certain time stages can be easily found and cited.

It is obvious that innovative development, the possibility of both producing and introducing innovations, is influenced by a much larger, multidirectional, and complex combination of parameters. We have proposed and considered only some of them, and the identification and subsequent analysis of such parameters are the subjects of further research. It is also necessary to conduct such studies in the context of variously formed groups of countries, for example, by geographical, demographic, socio-economic, socio-political, and, possibly, other characteristics. The identification of such dependencies is especially useful in the implementation of planning and management at various levels and in various fields of activity - from the economy to social security, from the global, regional, or national level to the management of a particular enterprise, firm, and their divisions. Accordingly, the managerial aspect is the most important component of the results obtained.

CONCLUSION

Thus, this study, conducted and presented by us, can be summarized by the main conclusions set out below. Development and implementation of innovations at all levels of socio-economic activity. Starting from individual enterprises and ending with states as a whole, it urgently requires a competent scientifically based management approach and dynamic strategic decision-making in the face of a significant number of uncertainties of various natures. At the same time, a reasonable definition of indicators that affect innovations or reflect their level of implementation is a very relevant scientific task. In order to successfully manage innovation activity at the country level as a whole, one should first select (determine) characteristic indicators, and then establish a connection between them and the success of innovation activity.

In our study, high and medium-developed countries were considered. The main useful contribution of the results obtained by us lies in the identification of the main significant indicators, which can be used by policymakers in the process of making practical managerial and other decisions. It was found that innovative parameters of the state (national level) should be considered:

- the total number of applications for trademarks of goods or services;
- the total number of patent applications for an invention, product, or process;
- the level of high-tech exports as a percentage of exports in general;
- the level of connections and cooperation between producers and researchers (rating in percentages in the range from 10%-low to 100%-high);
- the level of training and teaching activities (total percentage of firms supporting training programs for their staff);
- expenditure on research and development and projects (both public and private sector spending on research and development, measured as a share of GDP).
At the same time, the relationship between the number of scientific publications (as an indicator), in particular, articles in the fields of exact sciences, fundamental and applied technologies, humanitarian research, and the level of innovative development, in our case, was not confirmed. Perhaps further research should be done here.

Finally, it should be noted that the obtained and presented results can serve as a starting point for more detailed studies of various criteria for innovative activity and the level of innovation implementation. At the same time, the identified criteria can serve as a practical tool and be used in the process of management and measurement of innovation processes. As for the boundaries of research, it is obvious that innovation processes in the context of a global digital economy and the significant influence of various uncertainties are very dynamic and deeply connected with other economic processes of a very different nature. Therefore, the clarification of boundaries and limitations in this kind of research is a permanent necessary methodological component. This implies the corresponding directions for further research, in particular, a deeper structuring of indicators into components of a lower level, a comparison of the effect of these indicators over time, taking into account economic-geographical, socio-political, cultural-educational, and similar global factors.

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**Conflict of interests**

The authors declare no conflict of interest.

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