ECONOMICS OF DEVELOPMENT
Journal homepage: https://ecdev.com.ua/
Vol. 24, No. 1
2025

UDC 330.4
DOI: 10.63341/econ/1.2025.35

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Analysing innovation performance in the context of economic development

Abstract. The purpose of this study was to analyse the key characteristics of innovation in selected European countries and, based on this analysis, to determine the correlation between investment growth in innovative solutions and the dynamics of national economic development. The study examined such indicators of innovation processes as the volume of human capital, the number of scientific publications, the degree of digitalisation, public and private investment in innovation, intellectual assets, and the export of knowledge-intensive products across several European countries. A regression analysis was conducted to identify patterns in the development of national economies. The study covered the dynamics of innovation activity in Europe between 2016 and 2023, which allowed for identifying key development vectors in specific countries and determining the dependence of economic growth on financial investments in new technologies and the speed of their implementation. The results showed that Belgium and Denmark exhibited the highest levels of innovation activity, significantly exceeding the EU average, particularly in digitalisation, human capital development, and research attractiveness. Germany and France demonstrated stable but moderate growth in innovation indicators, while countries such as Poland and the Czech Republic showed positive but slower trends. Conversely, Bulgaria and Turkey ranked among the least innovative economies in the region. A regression analysis of the relationship between GDP and innovation index revealed that the correlation was not strictly linear. Some smaller economies with robust innovation policies outperformed larger ones in terms of innovation development. The findings highlighted the necessity of increasing both public and private investment in R&D, optimising funding mechanisms, and fostering stronger public-private partnerships to support innovation. The practical significance of the research lay in identifying predictable trends in innovation activity, highlighting the most promising areas for future investment, and pinpointing key applications for emerging technologies

Keywords: national economies; individual enterprises; efficiency; competitiveness improvement; investment in the future

INTRODUCTION

Each country's level of technological development determined its level of socioeconomic development. Experiments and research that led to the creation of new knowledge and technologies were what kept countries independent and in good health. In the context of the fifth technological mode, when the gap in economic development even for a few years could be critical for individual national economies, it was especially important to understand in advance the promising areas of science and technology development. Accordingly, the relevance of

Article's History: Received: 12.11.2024; Revised: 25.02.2025; Accepted: 25.03.2025

Suggested Citation:
Mehdi, F. (2025). Analysing innovation performance in the context of economic development. *Economics of Development*, 24(1), 35-44. doi: 10.63341/econ/1.2025.35.

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this research was to identify the experience of innovation activities of European countries and to guide investment flows to those branches of science and technology that will ensure the most intensive development soon. In addition, understanding the correlation between innovation activity and gross product will help to predict the potential of a particular national economy.

Equally important was the even innovation development of the regions. G.A. Kozhakhmetova & O.V. Lashkareva (2020), exploring the establishment and development of regional innovation systems in Kazakhstan, identified noticeable positive changes in the indicators of scientific-innovative development on the ground. They ranked the innovation activity of regions and major cities of the Republic of Kazakhstan and concluded that for maximum efficiency in several lagging regions (Turkestan, West Kazakhstan and Mangistau regions) it was necessary to establish special innovation clusters and ensure the exchange of information and experience with the leading regions.

An important aspect of innovation promotion was the budget allocated to research and development (R&D), as the full development of scientific research was impossible without the establishment of funding mechanisms and diversification of investment sources. This issue was discussed by N.K. Kuchukova & L.A. Talimova (2020), having determined that fundamental research financed from the state budget and private sources did not replace, but complemented each other. Therewith, the private sector was interested in exchanging information only at the early stages of new technology development, which meant that the state should have established a pool of consumers of scientific services, helping enterprises to buy the results of R&D through targeted funding of this sphere. Such a measure would increase the innovation activity of Kazakhstani enterprises and ensure the modernisation of the national economy.

In addition, the low level of Kazakhstani innovations was stated by G.I. Zholdasova (2021) – the share of R&D expenditures in Kazakhstan had decreased to 0.17% of gross domestic product (GDP), while in developed countries it had reached 4%. Therewith, such sphere of innovation application as the development of the digital economy was at a rather high level in the Republic of Kazakhstan, and according to the research by E.A. Georgieva *et al.* (2020), there was an increase in venture capital financing of digital projects and a positive impact of digital solutions on the labour market.

From the standpoint of sustainable development prospects, the work of G. Kalkabayeva *et al*. (2021) was of interest. The researcher noted the weak participation of Kazakhstan in the design and development of "green" technologies and eco-innovations, which increased the risks of maintaining a catch-up model of development and reduced the competitiveness of the national economy. As an alternative, the author proposed the establishment of a special institute for the development of the finance market by analogy with the special European Centre for the Development of Green Finance under the auspices of Organisation for Economic Co-operation and Development (OESD). Therewith, at this stage there was no fresh analysis of the degree of correlation between the level of innovation activity and the country's GDP. The purpose of this research was to cover this gap and to analyse the key indicators of innovation activity on the example of several European countries, and forecast the prospects for their development.

MATERIALS AND METHODS

During the research process, methods such as statistical analysis and forecasting were applied, and a regression analysis of indicators, along with the construction of a scatter diagram and the subsequent development of a trend, was carried out. The annual European Innovation Scoreboard (2023) provided a comparative assessment of the R&D and innovation activities of most countries in Europe and some other countries, analysing their strengths and weaknesses. It distinguished four main types of activity – key conditions, investment activity, innovation activity and impact factors – with 12 innovation dimensions covering a total of 32 indicators. Each major group included an equal number of indicators and was equally weighted in the average performance score, or the Composite Innovation Index.

Based on official data provided by the European Innovation Scoreboard (2023), the aggregate innovation index of ten national economies in Europe was analysed, and all key innovation parameters of this index were analysed. For the most representative sample, countries representing, according to the official terminology of the European Union, all four efficiency groups were selected. In particular, the group of innovation leaders was represented by Belgium and Denmark, the group of strong innovators by Germany and France, the group of moderate innovators by Italy and the Czech Republic, and the group of potential innovators by Bulgaria and Poland. In addition, two non-EU countries, the UK and Turkey, were included in the analysis for a more comprehensive assessment of the innovation situation in Europe.

For each country analysed, a total innovation index was considered, along with its 12 constituent innovation parameters. These parameters include the human resources growth index, which reflects the number of doctoral students, the proportion of the population with higher education, and the popularity of lifelong learning. Another key component was the index of attractive research systems, which assessed the accessibility and effectiveness of research institutions. The digitalisation index measured the proportion of areas covered by broadband internet and the number of individuals with digital literacy levels above the basic threshold. Additionally, finance and support include public sector R&D expenditure, venture capital investment, and state support for innovative businesses. The firm investments parameter evaluated the extent to which businesses allocate resources to innovation. An essential aspect of innovation was the indicator of the use of information technologies, which measured the penetration of IT solutions across various economic sectors. The innovators category assessed the proportion of enterprises engaged in product and process innovation. Moreover, the linkages indicator examined cooperation between innovative firms, as well as the mobility of human resources in technology-driven sectors. The intellectual assets parameter was calculated based on the total number of patents, trademark applications, and the number of intellectual property applications developed within the country. Furthermore, employment impacts reflect how innovation influences job creation and labour market dynamics. The

sales impacts parameter assessed the commercialisation of innovation-driven products and services. Lastly, environmental sustainability considered the implementation of eco-friendly technologies and resource-efficient production methods.

In addition, based on Eurostat (2023) data, a regression analysis between the innovation index of ten European states and their GDP was conducted. Based on the data obtained, a regression correlation was determined, and a linear trend was established after the construction of a scatter diagram to understand the prospects of innovation development in Europe and to determine the dependence of GDP on the innovative activity of a state and the success of its innovation projects. In addition, the innovation indices for the previous eight years were analysed for the selected countries. Although data for the European Innovation Scoreboard for 2024 were available, the analysis was conducted up to 2023 due to the lack of complete GDP data for all countries at the time of the study. Furthermore, the innovation indices for the selected countries were analysed for the previous eight years to understand the true dynamics, using the percentages of the innovation indices to the EU innovation average for 2016.

RESULTS

The EU's commitment to promoting an innovative culture was confirmed by the European Innovation Scoreboard (2023), which demonstrated a notable improvement in innovation performance of almost 8.5% since 2016. Twenty Member States saw a notable increase in their capacity for innovation during the last year, while only seven saw a decrease. During this time, the innovation performance of 25 countries increased, albeit more slowly than in the more recent years. However, nations with weaker innovation systems typically advance more slowly than the EU average. Since 2016, the majority of EU regions had seen an improvement in their innovation performance, according to the Regional Innovation Scoreboard. Some regional "pockets of excellence" were located in nations with comparatively poorer innovation performance, despite the fact that innovative regions were typically found in the most innovative nations. While the distance with Canada, the Republic of Korea, and the United States had widened, the EU was still performing marginally better than China and was catching up to Australia on a worldwide scale. Figure 1 depicts the annual percentage changes between two consecutive years and forms an overall dynamic trend.

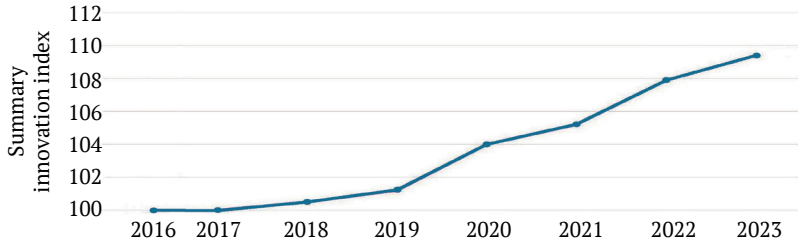

Figure 1. Improving innovation performance in the EU
Source: developed by the author based on European Innovation Scoreboard (2023)

When considering the 2023 results by country, the leaders with innovation ratios significantly above the EU average can be highlighted. In particular, Belgium demonstrated a result almost 30% higher than the EU average innovation coefficient. In addition, there was a significant excess of average indicators for most innovation parameters (Table 1).

Table 1. Key parameters for Belgium's innovative development in 2023

Indicator	Ratio to EU average
Human resources	124.8
Attractive research systems	155.6
Digitalisation	111.6
Finance and support	123.6
Firm investments	132
Use of information technologies	147.3
Innovators	146.5
Linkages	173.7
Intellectual assets	86.9
Employment impacts	150
Sales impacts	102.6
Environmental sustainability	101.7
Summary innovation index	125.8

Source: developed by the author based on European Innovation Scoreboard (2023)

This significant increase for Belgium was due to increased innovation, i.e. a notable externalisation of information technology, an increase in the attractiveness of working in science, and increased linkages. Linkages should be understood as cooperation between innovative firms, sustainable research connections between the private and public sectors, and the mobility of human resources between technology firms. The other examined country in the group of innovation leaders was Denmark. Its dimensions of innovativeness were summarised in Table 2.

Table 2. Key parameters for Denmark's innovative development in 2023

Indicator	Ratio to EU average
Human resources	176.7
Attractive research systems	189.5
Digitalisation	145.6
Finance and support	111.9
Firm investments	114.4
Use of information technologies	149.8
Innovators	117.2
Linkages	216.2
Intellectual assets	136.9
Employment impacts	107.9
Sales impacts	107.7

Table 2. Continued

Indicator	Ratio to EU average
Environmental sustainability	129.3
Summary innovation index	137.6

Source: developed by the author based on European Innovation Scoreboard (2023)

As can be seen, the final innovation rate in 2023 was one-third higher than the EU average and one of the highest on the continent. It was largely due to a significant increase in venture capital investment, increased digitalisation and linkages between knowledge-intensive areas of the economy. Germany's performance as a country in the second subgroup of innovation – strong innovators – was slightly below the leaders but was quite high (Table 3).

Table 3. Key parameters for Germany's innovative development in 2023

Indicator	Ratio to EU average
Human resources	99.8
Attractive research systems	109
Digitalisation	86.5
Finance and support	91.8
Firm investments	140.4
Use of information technologies	120.9
Innovators	141.1
Linkages	141.9
Intellectual assets	122
Employment impacts	128.4
Sales impacts	117.5
Environmental sustainability	121.2
Summary innovation index	117.8

Source: developed by the author based on European Innovation Scoreboard (2023)

Here, one of the strongest areas of development was the work of small and medium-sized enterprises, which take responsibility for innovations at the level of small private enterprises. Business investment in innovation by large non-state companies had a significant impact. The data for another representative of the group of strong innovators – France – were presented in Table 4.

Table 4. Key parameters for France's innovative development in 2023

Indicator	Ratio to EU average
Human resources	126.3
Attractive research systems	117.1
Digitalisation	112.3
Finance and support	132.7
Firm investments	89.7
Use of information technologies	73.8
Innovators	104.5
Linkages	120.9
Intellectual assets	80.6
Employment impacts	110.1
Sales impacts	81.7
Environmental sustainability	118.3
Summary innovation index	105.3

Source: developed by the author based on European Innovation Scoreboard (2023)

The strength of the French innovation policy was the visible finance and support and proper attention to the development of human resources. Therewith, the final indicators do not demonstrate breakthrough solutions and were at the level of the average arithmetic data of the European Union. The Czech Republic, despite the background of the East European socialist bloc, was able to join the ranks of developed economies quite quickly and establish its innovation policy. The main indicators of this activity for 2023 were summarised in Table 5.

Table 5. Key parameters of the Czech Republic's innovative development in 2023

Indicator	Ratio to EU average
Human resources	82.7
Attractive research systems	82.6
Digitalisation	76.7
Finance and support	82.1
Firm investments	113.2
Use of information technologies	100.4
Innovators	138.2
Linkages	94.1
Intellectual assets	63.1
Employment impacts	106.1
Sales impacts	103.1
Environmental sustainability	99
Summary innovation index	94.7

Source: developed by the author based on European Innovation Scoreboard (2023)

Despite a general level of innovation that was below the EU average, the Czech Republic had managed to take its rightful place in the group of moderate innovators due to the development and implementation of innovations in small and medium-sized enterprises. In addition, the state's ability and willingness to utilise borrowed and acquired information technology had given the innovative trend in the national economy the necessary impetus. The second representative of the group of moderate innovators was Italy. Despite a long tradition of enlightenment and innovation, the indicators of innovation development at this stage were relatively low and were presented in Table 6.

Table 6. Key parameters of Italy's innovative development in 2023

Indicator	Ratio to EU average
Human resources	62.1
Attractive research systems	106.2
Digitalisation	77.9
Finance and support	66.8
Firm investments	72.3
Use of information technologies	79.5
Innovators	115.2
Linkages	92
Intellectual assets	107.6
Employment impacts	107
Sales impacts	92.8
Environmental sustainability	113.4
Summary innovation index	90.3

Source: developed by the author based on European Innovation Scoreboard (2023)

As can be seen from the table, the country's potential was growing, largely due to government policies to stimulate the scientific sphere and its intellectual assets. High indicators of environmental sustainability, including resource efficiency, reduction of harmful emissions into the atmosphere and development of environmental technologies, deserve special attention. In particular, the data for Poland were summarised in Table 7.

Table 7. Key parameters of Poland's innovative development in 2023

Indicator	Ratio to EU average
Human resources	58.3
Attractive research systems	46.2
Digitalisation	81.1
Finance and support	61.2
Firm investments	59.3
Use of information technologies	90.3
Innovators	41.4
Linkages	73.7
Intellectual assets	84.2
Employment impacts	50.8
Sales impacts	68.2
Environmental sustainability	43.8
Summary innovation index	62.8

Source: developed by the author based on European Innovation Scoreboard (2023)

Despite the relatively low performance in almost all categories of innovation activity, the growth of digitalisation of the country and its population can be highlighted, as intellectual assets, which include various forms of intellectual property rights established in the process of innovation, including patent applications and trademark applications. On these parameters, the country was almost approaching the European average. Another country in the group of potential innovators was Bulgaria. Its indicators were presented in Table 8.

Table 8. Key parameters of Bulgaria's innovative development in 2023

Indicator	Ratio to EU average
Human resources	32.7
Attractive research systems	26.6
Digitalisation	49.8
Finance and support	22.1
Firm investments	35
Use of information technologies	48.1
Innovators	56
Linkages	35.4
Intellectual assets	92.5
Employment impacts	56.7
Sales impacts	59.7
Environmental sustainability	46.2
Summary innovation index	46.7

Source: developed by the author based on European Innovation Scoreboard (2023

At this stage, Bulgaria was in the rear-guard of European economies, and its total innovation score was not even half of the EU average. Therewith, a relatively high level of sales impact can be recognised, including exports of medium- and high-tech products, exports of knowledge-intensive services and sales of the results of the introduction of innovative products. In addition to the countries of the European Union, it was essential to explore the innovation performance of its neighbours to provide additional external criteria for assessing performance on the one hand and, on the other hand, to monitor the innovation potential of the EU's trading partners in advance. The UK, having left the EU, remains one of the most important economies on the continent with a large innovation potential. Its performance for 2023 was summarised in Table 9.

Table 9. Key parameters of the UK's innovation development in 2023

Indicator	Ratio to EU average
Human resources	161.5
Attractive research systems	170.6
Digitalisation	39.1
Finance and support	122.6
Firm investments	76.2
Use of information technologies	120.2
Innovators	48.1
Linkages	206.5
Intellectual assets	70.4
Employment impacts	147.3
Sales impacts	106.8
Environmental sustainability	116.1
Summary innovation index	114.8

Source: developed by the author based on European Innovation Scoreboard (2023)

In general, the innovation rate of almost 120% corresponds, according to the EU classification, to the group of "strong innovators". The indicators that allow deriving such an impressive coefficient deserve particular attention – they were linkages, the attractive research systems in the state, and a high assessment of human resources. In the context of the geopolitical situation, it was particularly important to assess the innovative activity of Turkey, which historically had been a "bridge" between Europe and Asia. According to the dynamics of development and introduction of modern technological innovations by this state, it was possible to develop forecasts regarding the innovation potential of both Central Asian and Transcaucasian regions. Turkey's coefficients for 2023 can be found in Table 10.

Table 10. Key parameters of Turkey's innovative development in 2023

Indicator	Ratio to EU average
Human resources	48.5
Attractive research systems	45.6
Digitalisation	36.6
Finance and support	68.6
Firm investments	46.8
Use of information technologies	32.6
Innovators	58.4
Linkages	64.7
Intellectual assets	27.1
Employment impacts	23.1
Sales impacts	65.9

Table 10. Continued

Indicator	Ratio to EU average
Environmental sustainability	44.1
Summary innovation index	47.6

Source: developed by the author based on European Innovation Scoreboard (2023)

The indicators at this stage were relatively low and were less than half of the average European innovation rate. Attention should be devoted to such indicators as the attraction of innovative technologies and the impact on employment – the figures for these indicators were extremely low, which may indicate the potential for the development of these areas. In addition to assessments of innovation activity as of 2023, "at the moment", it was equally important to understand the dynamics of the process. Having the trend of indicators in comparable values, it was possible to characterise the development of the national investment policy and get an idea of its near future. Due to the website of the European Innovation Scoreboard, it was possible to obtain data from 2016 onwards (Table 11).

Table 11. Dynamics of the innovation development index

Year	2016	2017	2018	2019	2020	2021	2022	2023
Belgium	122.3	123.7	125.9	129.3	127.6	136	136.9	136.4
Denmark	133.3	134.5	134.2	137.8	140.1	144.5	146.5	149.2
Germany	120.2	120.4	121.1	121.6	122.1	127.1	129	127.8
France	115.8	115.6	116.4	114.2	114.7	113.1	115.5	114.2
Czech Republic	81.7	81.7	82.1	83.2	85.7	89.1	92.3	102.7
Italy	82.4	83.6	84.4	89.9	92.9	102	103.6	98
Poland	54.8	56.4	56.5	58.9	58.3	61	62.9	68.1
Bulgaria	46.3	45.9	44.8	46.3	46.9	45.1	44.6	50.6
UK	123.3	126.9	128.2	128.5	130.3	124.7	127.1	124.5
Turkey	51.2	52.4	54.5	60.5	61.5	51	50.9	51.6

Source: developed by the author based on European Innovation Scoreboard (2023)

As can be seen from the data, for Belgium, innovation had a noticeable constant growth except for a slight decline in 2016. According to the table, after five years of relative stability, there was an explosive surge in innovation performance in 2021 and the positive trend continued in the following years in Denmark. Germany saw a major jump in the index in 2021 after several years of relative stability. Therewith, this country, unlike the innovation leaders Belgium and Denmark in 2023, failed to maintain the trend and experienced a decline in the final index. The picture of innovation in France differs significantly from that of previous national economies. After the peak in 2018, the indices declined. The small "rebound" in 2022 was too insignificant to make a significant difference. The Czech economy, although lagging behind the absolute indicators of "Old Europe", demonstrates constant and steady growth in relative terms. The same applies to innovation policy.

Italy's innovation performance was in line with the EU average for the 2016 sample. Having received small impulses in 2019 and 2021, the rest of Italy's innovation activity had been stagnant, and after eight years, the innovation index had only reached the EU average of 2016. From the group of the weakest countries in terms of investment, Poland was distinguished by its relatively strong dynamics and potential. As can be seen from the Table 11, the Poland's innovation activity sometimes demonstrates minimal growth values, nevertheless, the trend was positive throughout the entire period of observation. It was not the case for Bulgaria – the country's innovation index was in chaotic movement and after periods of upswing there were sharp declines in 2018 and 2021. Further monitoring of the innovation indices was needed to understand the subsequent dynamics.

Of the non-EU European countries, the UK has the largest economy. The Table 11 demonstrates a strong growth of the index until 2020 and a sharp decline in 2021. Therewith, notably, despite such shocks, the UK's innovation index was still well above the EU average. Turkey, as a logistics hub between Europe and Asia, is important in terms of innovation policy development. Based on the data in the Table 11, it can be argued that innovation development in Turkey was practically non-existent – the country was still at the level of 50% of the EU innovation potential of 2016. Moreover, this indicator was virtually unchanged from year to year, which means that a significant external impetus was required to turn the situation around.

Thus, 12 categories of innovation indicators for 2023 and the dynamics of aggregate indices of a number of countries for 8 years were analysed. Therewith, for the fullest possible understanding of the further development of innovation in the European Union, it was necessary to determine the relationship between innovation indicators and the country's GDP. Table 12 summarises these indicators for a number of examined countries in 2023, the latest year for which the World Bank had published official information. Since there was a notable variation in the correlation between the level of innovation and GDP, to determine the mathematical relationship between the two, a regression analysis of the data was conducted (Table 13).

Table 12. Key indicators of the countries examined

Country	Innovation Index-2023	GDP-2023, million $
Belgium	136.4	644,782
Denmark	149.2	407,091
Germany	127.8	4,525,703
France	114.2	3,051,831
Czech Republic	102.7	343,207
Italy	98	2,300,941
Bulgaria	50.6	102,407
Poland	68.1	809,200
UK	68.1	3,380,854
Turkey	51.6	1,118,252

Source: developed by the author based on GDP (current US$) (2023)

Table 13. Regression statistic

Multiple *R*	0.145238568
R-square	0.021094241
Standardised *R*-squared	-0.101268978
Standard error	1,614,366.766
Observations	10
Y-intersection	1,062,578.9067
Variable *X*1	6,267.175889

Source: developed by the author

These results indicate a weak correlation between the 2023 Innovation Index and the GDP of the countries. The *R*-square value suggests that only about 2.1% of the variation in GDP was explained by the level of innovation development. With a noticeable degree of error, the correlation between the innovation index and GDP can be determined by the formula (1):

$$GDP = 1{,}062{,}578 + 6{,}267 \times I_i, \quad (1)$$

where I_i – innovation index. Thus, the obtained results identified innovation leaders by key parameters of innovation activity and determined the dynamics of innovation policy development in several European countries. A regression analysis of the relationship between GDP and innovation was conducted, which did not identify a strong correlation between these indicators.

DISCUSSION

The subject of innovation development as the most important factor in stimulating national economies and improving civilisation, in general, attracts the deserved attention of many researchers. The issue of innovation had become especially relevant with the emergence of the Internet and the subsequent digital technological breakthrough. K. Mtar & W. Belazreg (2021), exploring the causal link between innovation, financial development and economic growth in the OECD countries, found that there was a unidirectional causal connection between the elements examined. The authors concluded that further regulation of financial systems and the quality of finance were critical to stimulating economic development, and national governments can play an important role in developing legislative frameworks that favour the development of innovation financing through patent guarantees. In addition, M. Capriati (2022) identified a complementary connection between innovation and human capital development, and innovation and a country's GDP. The researcher concluded that it was crucial to define human development as the ultimate purpose of innovation policy and that it was necessary to develop a macroeconomy designed to fully implement the potential of citizens. This research confirms the correlation between innovation and the economic development of a state – the higher the standard of living in a country, the higher its innovation rating.

I.A. Bathuure (2021) determined in his work the impact of social innovation on economic growth in the example of 147 countries proved that investments in digital communication technologies should be a priority, as they significantly reduce the cost of establishing and maintaining personal connections of employees, which positively affects labour productivity. In addition, innovation plays an important role in the global project of sustainable development. R.Y. Castillo-Acobo *et al.* (2023) explored the impact of innovation and willingness to transform closed-loop economies into environmentally sustainable models. In the process, the authors obtained evidence of a positive relationship between innovation adoption and sustainable development. A similar aspect of innovation was explored by J. Kučera & M. Fiľa (2022) and K. Belanova (2024). P. Nunes & K. Sytnychenko (2024) and R.R.N. Ghormare *et al.* (2024) identified the main components of the circular economy, identified the impact of these variables on the economic growth of the European Union countries and proved that all three components of sustainable development – environmental, social and economic – were significant for GDP growth. Therewith, as the results of this work confirm, there was no straight correlation between GDP volume and innovation index, and countries with smaller economies (Belgium, Denmark) overtake such European economic giants as Germany or the United Kingdom in terms of innovation development.

R. Bago *et al.* (2023) were able to identify the most relevant innovation areas for investment activities. By assessing the correlation between the volume of exports of high-tech products and the volume of net portfolio investment, they managed to rank 130 countries examined by four categories of efficiency of investment in innovative developments. This research confirms the attractiveness of investment areas such as digitalisation and human capital development. To explore more fully the impact on human capital development of such an aspect of innovation as modern university education,

T. Agasisti & A. Bertoletti (2022) conducted a longitudinal study of European regions between 2000 and 2017. The duration of the experiment allowed maximising the impact of innovation and almost eliminating the factor of randomness. The result was an unambiguous conclusion that innovation in R&D activities was an important driver of GDP per capita growth in the region, regardless of the form of ownership of the educational institution. By analysing the level of individual firms, E. Chalioti *et al.* (2020) found that as competition between exporters of a non-innovative product becomes more intense, an innovative firm export more compared to its non-innovative competitors in more distant markets and confirmed this hypothesis empirically using the example of Greek exporting firms. Thus, it can be concluded that reorientation towards operating with innovative products was a profitable alternative to operating in an oversaturated "conventional" product market. Indirect confirmation of this conclusion was obtained in the present research, where it was demonstrated that an increase in the Sales Impact Index tended to correspond to an increase in the Generalised Innovation Activity Index.

Either way, a modern enterprise can use changes in the innovation market environment as an opportunity to establish new products and services that constitute a competitive advantage defined by the business strategy adopted. S. Pangsy-Kania *et al.* (2023) explored the relationship between business strategies used in industrial enterprises and their effects in the form of different types of innovations. Based on statistical data for several EU countries, a cluster analysis was conducted and the hypothesis was confirmed that the importance of business strategies for innovative companies varies from country to country and combinations of different innovation strategies were the most effective. Another important aspect of innovation development was the ability of authors of an invention or discovery to protect their intellectual property. The lack of effective patenting and royalty mechanisms can significantly reduce or even stop R&D altogether. It was particularly true for companies in the private sector. S. Kwon (2020) examined how a firm's acquisition of external patents affects the innovation activities of competing firms. By analysing the literature on patent delays and examples of firms' strategic use of patents, the researcher confirmed the hypothesis that the purchase of an external patent constrains the development of relevant technologies within a competitive environment.

Consequently, a balance between intellectual property protection and the ability of the rest of the market to legally utilise innovative achievements was necessary for the development of innovation. D. Hegde *et al.* (2023) examined a large-scale natural experiment – the passage of the American Inventors Protection Act of 1999 – which accelerated the public disclosure of most U.S. patents by two years. After the Act went into effect, U.S. patents were cited more frequently and more quickly, fuelling the diffusion and dominance of U.S. technologies against lagging European patents whose disclosure timelines were not changed. Thus, the patent activity of a country was a marker of the activity of its investment activity. For a more complete assessment of innovation efficiency, L. Ponta *et al.* (2021) proposed to introduce a special patent index IPI, which allows quantitatively summarising various aspects of innovation activity of firms. In their work, the authors, using three different machine learning algorithms, identified five key aspects of IPI – efficiency, time, diversification, quality and internationalisation – and proved that this method was effective, easy to use and indispensable in planning innovation potential.

M. Dritsaki & S. Dritsaki (2023) and A.F. Bate *et al.* (2023) examined the relationship between R&D expenditure and the global innovation index across countries. The results of the research demonstrated a long-term positive significant relationship between R&D investment and the innovation index, whereas in the short term, the correlation was negative. Similar trends in the European investment market were observed in this research. The experience of the above authors helped to define the background of investment activity and identify its specific features in the context of real markets, primarily European. Comparing the results of this work with the experience of other studies, it can be stated that there was no stable regression relationship between the innovative activity of the state and the size of its GDP.

CONCLUSIONS

The European Union's dedication to promoting innovation was reaffirmed by the European Innovation Scoreboard 2023, which also noted a consistent improvement in innovation performance over the previous eight years. Overall, the EU's innovation growth since 2016 was about 8.5%, with most Member States exhibiting encouraging trends. To guarantee balanced development, additional national and regional policy measures were required, as the continent's progress was still uneven. The examination of important innovation metrics shows that Belgium and Denmark have solidified their positions as leaders, outperforming the EU average in several areas, most notably in the areas of digitalisation, research system attractiveness, and human capital development. Despite their relatively modest growth rates, Germany and France were still in a good position. Though at a slower rate, up-and-coming innovators like Poland and the Czech Republic have shown encouraging trends. On the other hand, with only modest gains seen in their respective innovation indexes, Bulgaria and Turkey continue to rank among the least inventive economies in the area.

Although there was a broad association, regression study of the relationship between GDP and innovation performance showed that it was not strictly linear. In terms of innovation production, certain smaller economies – like Belgium and Denmark – that had robust innovation policies perform better than larger ones like Germany and the UK. This implied that, regardless of GDP size, focused innovation policies, calculated R&D expenditures, and improved public-private sector collaboration were essential for promoting innovation. The results highlighted the need for more public and private investment in R&D, clear funding procedures, and improved support systems for start-ups and tech-driven businesses from a policy standpoint. To further reduce the innovation gap within the EU, it will be crucial to establish regional innovation hubs and promote cross-border cooperation. Furthermore, in order to guarantee a sustainable

knowledge-based economy, methods for retaining talent must be given top priority. Finding recurring patterns in the growth of innovations and emphasising important areas for further investment were the research's practical implications. Further research is required to examine the long-term effects of emerging technologies, the role of artificial intelligence in innovation ecosystems, and the efficacy of governmental innovation policies in various economic contexts, even though the study offers insights into the current state of innovation in Europe.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

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Аналіз ефективності інновацій в контексті економічного розвитку

Анотація. Метою цього дослідження було проаналізувати ключові характеристики інновацій у вибраних європейських країнах і, на основі цього аналізу, визначити кореляцію між зростанням інвестицій в інноваційні рішення та динамікою економічного розвитку держав. У межах дослідження були розглянуті такі показники інноваційних процесів, як обсяг людського капіталу, кількість наукових публікацій, рівень цифровізації, державні та приватні інвестиції в інновації, інтелектуальні активи та експорт наукомісткої продукції у кількох європейських країнах. Було проведено регресійний аналіз для визначення закономірностей розвитку національних економік. Дослідження охоплює динаміку інноваційної активності в Європі у період з 2016 по 2023 роки, що дозволило визначити ключові вектори розвитку окремих країн і встановити залежність економічного зростання від фінансових інвестицій у нові технології та швидкості їх впровадження. Результати показали, що Бельгія та Данія демонструють найвищий рівень інноваційної активності, значно перевищуючи середні показники ЄС, зокрема за рівнем цифровізації, розвитку людського капіталу та привабливості наукових досліджень. Німеччина та Франція демонструють стабільне, але помірне зростання інноваційних показників, тоді як Польща та Чехія мають позитивні, але більш повільні тенденції. Водночас Болгарія та Туреччина опинилися серед найменш інноваційних економік регіону. Регресійний аналіз взаємозв'язку між ВВП та індексом інновацій показав, що ця кореляція не є строго лінійною. Деякі менші економіки з ефективною інноваційною політикою демонструють вищий рівень розвитку інновацій, ніж більші країни. Отримані результати підкреслюють необхідність збільшення як державних, так і приватних інвестицій у сферу R&D, оптимізації механізмів фінансування та зміцнення державно-приватного партнерства для підтримки інновацій. Практичне значення дослідження полягає у визначенні прогнозованих тенденцій інноваційної активності, виділенні найбільш перспективних напрямів для майбутніх інвестицій та визначенні ключових сфер застосування новітніх технологій

Ключові слова: національні економіки; окремі підприємства; ефективність; підвищення конкурентоспроможності; інвестиції в майбутнє