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Economic efficiency of investment in innovation in a knowledge-based economy

Abstract. The purpose of the study was to analyse the impact of gross domestic expenditure on research and development on key indicators of knowledge-based economy performance in the short- and long-term using data from developed and developing countries. The results of the study showed an increase in attention to investment in innovation in a global sense. The leading countries and regions for investment in innovation are the United States of America, the EU, China, and Japan. Regression analysis of the short-term impact of gross domestic expenditure on research and development on key indicators of economic efficiency (level of human development, productivity, and gross domestic product (GDP) per capita) revealed a statistically significant impact only on the indicator of the level of human development. But the analysis of the long-term impact of this indicator on the example of data from the EU countries revealed the statistical significance of this impact on all dependent variables. This proved that investments in innovation have a cumulative effect that manifests itself in the long term. The identified impact on the indicator of the level of human development in both the short and long term indicates the fundamental role of investment in innovation in such development. The analysis of data from Kosovo revealed an inverse correlation between gross domestic expenditure on research and development and GDP per capita and human development. This revealed the low efficiency of investment in innovation in the country and suggested that Kosovo may need more time to achieve a positive cumulative effect from investments. Accordingly,

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the government of Kosovo should build on the successful international experience of developed countries in developing innovation investment initiatives and establishing international cooperation. In addition, investing in innovation may not have an immediate positive effect, and it takes longer to achieve it

Keywords: gross domestic expenditure on research and development; human development index; productivity; gross domestic product per capita; cumulative effect; short-and long-term perspective; level of development

INTRODUCTION

Industry and agriculture are priority sectors of the economy for developing countries. In turn, advanced economies focus their efforts on the development of the service sector, an important element of which is knowledge-based activities. This concept is called the "knowledge economy" or "knowledge-based economy". The key factor in the development of a knowledge-based economy is human capital, in particular, its intellectual abilities and knowledge (Novykova *et al.*, 2022). An important role is played by investment in innovation, which provides the development of a knowledge-based economy with wider opportunities for creating new knowledge. The pace of transition to a knowledge-based economy on the part of developing countries, in particular Kosovo, is significantly delayed (Phale *et al.*, 2021; Fazliu, 2024). During the last reporting period, Kosovo has achieved very limited progress in research and development (R&D). The country did not maintain previous results in the EU research and innovation framework, and most of the Commission's recommendations from the previous year remained unfulfilled (Kosovo 2024 report, 2024). Improving the quality of education and aligning existing educational approaches with market requirements remain key challenges (Melnikova & Gilsanz, 2024). In addition, Kosovo lags significantly behind in terms of funding for research and innovation, because in 2024 only EUR 15 million were allocated for R&D, which is about 0.1% of GDP, and according to the law, this figure should be at least 0.7% of GDP (Law of the Republic of Kosovo No. 04/L-135, 2013). Kosovo's Horizon Europe results also declined significantly in 2023, with a drop of about 75% compared to the previous period. Among the positive aspects is the support of female students by the Ministry of Education, Science, Technology and Innovation, although the country lacks a clear gender strategy (Kosovo 2024 report, 2024).

Problems in the development of innovation activities in Kosovo encourage national researchers to carefully analyse successful world practices and find ways to solve existing challenges. L. Aliu Mulaj & B. Dedaj (2022) concluded that achieving long-term success in the economy requires constant innovation. Researchers noted the importance of intellectual human capital and science for effective technological development and investment in R&D. A comparison was made between the share of R&D in the GDP of thirty countries, including the Balkan countries. The researchers concluded that investment in R&D in the Balkan countries significantly lags behind the indicators of economically powerful countries. The comparison was made to assess different opinions, which can lead to the identification of ways to increase economic growth. G. Jusufi & S. Ajdarpasic (2020) assessed the impact of EU research and education programmes on higher education institutions in the Balkan countries, focusing on Kosovo. It was found that higher education institutions in the region lack the financial capacity to update curricula, programmes, and develop research projects. That is why national educational institutions should rely on EU research programmes that can solve the funding problem. The need for close cooperation with the EU was also emphasised by Z. Dedaj (2022), who noted that at the present stage, the efforts of universities to create knowledge in Kosovo are contradictory, but the positive aspect is the deepening of cooperation with international donors such as the EU.

E. Krasniqi *et al*. (2020) demonstrated the structure of Kosovo's R&D initiatives. The researchers noted that Kosovo's economy has experienced some growth, not least due to consumption and investment. However, the number of innovative enterprises in the country remains quite small. According to Z. Dedaj *et al*. (2022), innovation processes and knowledge circulation between enterprises can be stimulated through open innovation. However, a significant proportion of companies operating in the innovation sector in Kosovo are not familiar with the mechanisms of innovation relations. Using the example of two successful companies in Kosovo, it was found that the main source of innovation is investment in R&D. Such investments would allow companies to gain access to the new equipment and skilled labour necessary for successful innovative development. In most of the research papers, there was a lack of information about investments in R&D in Kosovo. Moreover, little attention has been paid to comparing the short- and long-term effects of such investments. This study sought to fill in the gaps identified by summarising available information on Kosovo's innovation and investment activities and analysing the impact of investment in innovation using the example of leading countries. The purpose of the study was to analyse the impact of R&D costs on the main indicators of the effectiveness of a knowledge-based economy in the short and long-term using the example of countries with different levels of development.

MATERIALS AND METHODS

The research procedure was initiated with the disclosure of the indicator of investment in R&D in a knowledge-based economy. A statistical analysis of the indicators of total global spending on R&D (Total global spending..., 2022) and R&D investment by industry and world region (Distribution of the 2,500..., 2024) was carried out. Analysis of the first of the presented indicators determined the rapid growth of the indicator values. The analysis of the second indicator provided an opportunity to identify which regions of the world are leaders in R&D investment, including priority industries for investment. These indicators enabled a rapid analysis of the status and priority areas of investment in R&D. However, in the subsequent course of the study, the gross domestic expenditure on research and

development (GERD) indicator was used (Leading countries..., 2024). This indicator is more indicative, because it allows estimating investment in R&D as a percentage of GDP in individual countries, eliminating the impact of the absolute size of the economy.

A predictor of the development of the knowledge economy is human capital, which justifies the introduction of the Human Development Index (HDI) into the analysis (Human Development Index..., 2024). This indicator can demonstrate long-term changes in human development that form the basis for the development of a knowledge-based economy. Along with the noted indicator, an indicator of labour productivity was included in the analysis process (GDP per hours worked), which is effective for evaluating current economic activity (Most productive countries, 2024). The analysis also includes the GDP per capita indicator, which assesses well-being and characterises the potential for further development in a knowledge-based economy. HDI, GDP per hours worked, and GDP per capita were the main indicators of economic efficiency of the countries under study. The characterised indicators became the information basis for conducting correlation and regression analysis, during which the GERD indicator acted as an independent variable, and HDI metrics, GDP per hours worked, and GDP per capita (alternately) – as dependent. The idea of the study was to conduct correlation and regression analysis in two stages. Initially, indicators for a number of leading countries for a single period were taken to assess the short-term impact of investment in innovation on economic efficiency (Table 1).

Table 1. Data for Stage 1 of the correlation and regression analysis

Region	GERD, % of GDP	GDP per capita	HDI	GDP per hours worked
Austria	3.2	56,505.97	0.926	95
Belgium	3.41	53,475.29	0.942	100
Czech Republic	1.96	30,427.42	0.895	57
Denmark	2.89	67,967.38	0.952	104
Estonia	1.78	29,823.75	0.899	55
Finland	2.96	53,755.91	0.942	85
France	2.18	44,460.82	0.91	87
Germany	3.13	52,745.76	0.95	91
Greece	1.49	22,990.01	0.893	45
Hungary	1.39	22,147.21	0.851	52
Iceland	2.66	78,811.06	0.959	90
Ireland	0.96	103,684.9	0.95	163
Italy	1.32	38,373.17	0.906	74
Japan	3.41	33,834.39	0.92	53
Latvia	0.76	23,184.31	0.879	58
Lithuania	1.02	27,102.78	0.879	61
Luxembourg	0.98	128,259.4	0.927	131
Netherlands	2.3	62,536.73	0.946	92
Norway	1.56	87,961.78	0.966	162
Poland	1.46	22,112.86	0.881	56
Portugal	1.7	27,275.11	0.874	56
Slovakia	0.98	24,470.24	0.855	57
Slovenia	2.11	32,163.51	0.926	62
South Korea	5.21	33,121.37	0.929	50
Spain	1.44	32,676.98	0.911	69
Sweden	3.41	56,305.25	0.952	96
Türkiye	1.32	12,985.75	0.855	61
United States	3.59	81,695.19	0.927	92
China	2.43	12,614.06	0.788	14.6

Source: compiled by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), GDP per capita (current US$) (2024), Human Development Index (HDI) by country 2024 (2024), Most productive countries (2024)

The second phase covered indicators for a single region (EU countries) over a ten-year period to assess the long-term impact of R&D investment on the economic efficiency (Table 2).

Table 2. Data for Stage 2 of the correlation and regression analysis

Period	GERD, % of GDP	GDP per capita	HDI (average)	GDP per hours worked
2013	1.58	46,003.71	0.874	55.2
2014	1.59	46,657.58	0.876	55.8
2015	1.91	47,656.09	0.878	56.7
2016	1.91	48,517.05	0.88	57.4

Table 2. Continued

Period	GERD, % of GDP	GDP per capita	HDI (average)	GDP per hours worked
2017	1.91	49,894.32	0.882	58.1
2018	1.85	50,933.56	0.884	58.9
2019	1.99	51,884.56	0.885	59.6
2020	2.01	48,901.39	0.886	59.2
2021	1.91	51,916.83	0.886	60.3
2022	2.17	53,758.88	0.887	61

Source: compiled by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Most productive countries (2024), Human Development Index (HDI) by country 2024 (2024)

An additional stage of work was the correlation and regression analysis based on data from Kosovo (Table 3). Access to data for analysis for Kosovo is very limited, in particular, there is no data on the indicator GDP per hours worked and GERD. The first of these indicators was not considered in the analysis, because it is partially compensated by data on other dependent variables – HDI and GDP per capita. However, GERD as the only independent variable in the analysis cannot be excluded, so the paper used the average GERD for the Balkan countries instead of the GERD indicator for Kosovo.

Table 3. Data for an additional stage of correlation and regression analysis based on Kosovo data

Period	GERD, % of GDP (Balkans average)	HDI	GDP per capita
2010	3.333333	0.713	2.981
2011	0.9	0.722	3.524
2012	1.025	0.732	3.411
2013	0.88	0.736	3.705
2014	0.86	0.741	3.903
2015	0.8	0.746	3.521
2016	0.74	0.749	3.759
2017	0.74	0.754	4.009
2018	0.78	0.757	4.384
2019	0.78	0.756	4.416
2020	0.9	0.755	4.311
2021	0.925	0.756	5.271
2022	0.533333	0.757	5.291

Source: compiled by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Kosovo GDP per capita 2008-2024 (2024), Subnational HDI (v8.1) (2024)

The selection of countries and regions for analysis considered the data of statistical analysis, which helped to identify the leading countries in R&D investment. Focusing on data from advanced countries allowed assessing the specifics of investing in R&D in countries that set trends in global innovative development. Consideration of the data from Kosovo helped to assess the relationships under study using the example of a developing country. The final data sample was compiled after multicollinearity analysis, and the exclusion of individual countries for which data were not available on official sources of information. The analysis used data for 2022, because these were the latest data available on official sources.

RESULTS AND DISCUSSION

Statistical overview of key trends in innovation investment

Knowledge-based economics focuses on the production and sale of innovations and research results, such as scientific discoveries, which are transformed into commodities by applying various mechanisms to protect intellectual property. Investments provide activities related to research and innovation development with the necessary funds and resources. The structure of the R&D indicator provides an idea of the world leaders in investment in innovation, and priority industries for investment. Figure 1 shows the dynamics of Total global spending on R&D during the period from 1996 to 2022.

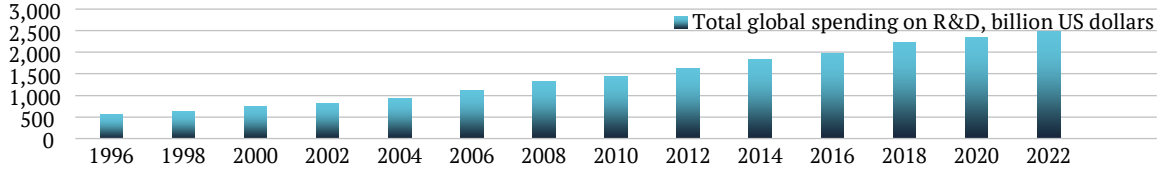

Figure 1. Global spending on R&D

Source: compiled by the authors based on Total global spending on research and development (R&D) from 1996 to 2022 (2022)

As can be seen from Figure 1, spending on R&D has only increased over the past quarter-century, and global spending has increased almost 4.5-fold over this period. The only period when the indicator experienced some decline was 2020. The main players in the R&D market are developed countries, in particular, the United States of America (USA) and the EU countries, although China and some other countries make a great contribution (Fig. 2).

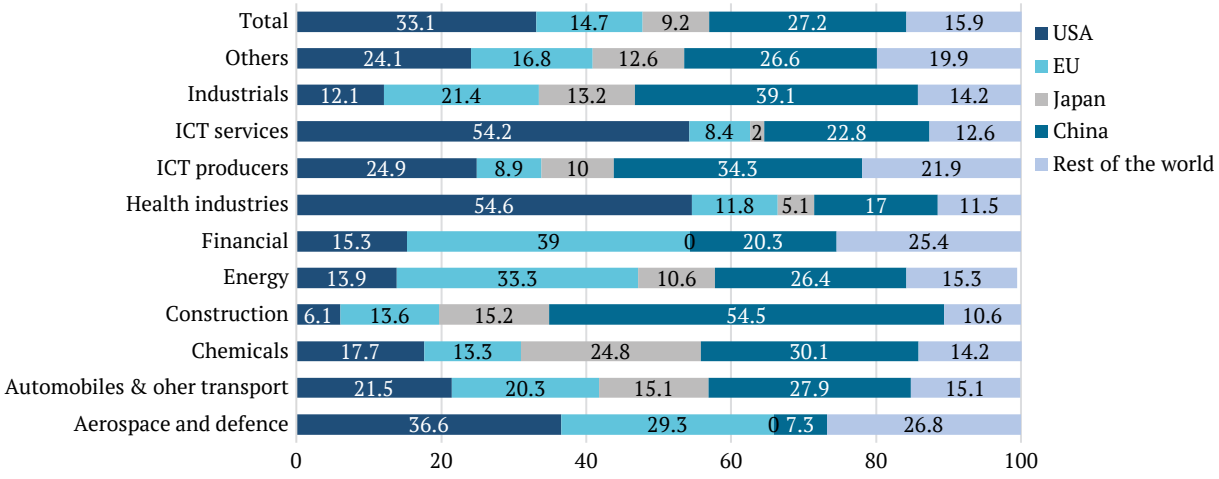

Figure 2. Countries' investment in R&D by industry, billion EUR

Source: compiled by the authors based on Distribution of the 2,500 leading global research and development (R&D) spending companies in 2022, by region and industry (2024)

As can be seen from Figure 2, the leader in investment in priority industries is the United States. The EU, China and Japan also play an important role. Along with material investment, the effective use of human knowledge and intellectual experience is important in the knowledge-based economy. The development of human capital is a key predictor of the transition to a knowledge-based economy, because it provides the basis for its development (Bokovets *et al.*, 2024). Potentially, between investments in innovation, in particular the GERD indicator, and the HDI indicator, GDP per hours worked, and GDP per capita have a mutual relationship. These indicators show the effectiveness of a knowledge-based economy, because they describe such efficiency at the intersection of the economic and social spheres. They comprehensively characterise human capital as a key element of a knowledge-based economy in terms of intellectual and physical potential, productivity, and well-being, forming the basis for short-and long-term growth. Thus, by measuring the impact of investment in innovation on the observed indicators, it is possible to describe the economic efficiency of investment in innovation in a knowledge-based economy.

Correlation and regression analysis of the short-and long-term impact of investment in innovation according to data from leading countries

At this stage of correlation and regression analysis, the short-term impact of investment in innovation was analysed. For this purpose, the GERD indicator and knowledge-based economy performance indicators – GDP per capita, HDI, and GDP per hours worked – were used to sample countries over a single time period (Table 4). The results of correlation analysis for a sample of countries over a single period do not show a close correlation between GERD and performance indicators of knowledge-based economics.

Table 4. Results of correlation analysis for a sample of countries for a single period

GERD, % of DGP	GDP per capita	HDI	GDP per hours worked
1			
0.081899934	1		
0.404316266	0.70345033	1	
−0.038939625	0.88735315	0.742319	1

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), GDP per capita (current US$) (2024), Most productive countries (2024), Human Development Index (HDI) by country 2024 (2024)

There is a fairly strong relationship between GDP per capita, HDI, and GDP per hours worked indicators. This indicates a complex mutual influence between the studied indicators, in particular, it can be assumed that human capital and productivity form the basis for improving the overall well-being of the population. Table 5 shows the results of regression analysis between GERD indicators (as an independent variable) and GDP per capita for sample countries for one period. The resulting model has little explanatory power, and the effect of GERD on GDP per capita is not statistically significant in the short term. Statistical significance Intercept ($p < 0.05$) indicates the possible existence of influential variables not considered in the calculations. The next stage of regression analysis describes the effect of the GERD indicator on HDI (Table 6).

Table 5. Results of regression analysis for a sample of countries for a single period, dependent variable – GDP per capita

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	41,936.57	12,289.8	3.41	0	16,719.99	67,153.15	16,719.99	67,153.15
GERD, % of DGP	2,179.14	5,103.39	0.43	0.67	−8,292.15	12,650.43	−8,292.15	12,650.43

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), GDP per capita (current US$) (2024)

Table 6. Regression analysis results for a sample of countries for a single period, dependent variable – HDI

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	0.88	0.02	53.73	0	0.84	0.91	0.84	0.91
GERD, % of DGP	0.02	0.01	2.3	0.03	0.00	0.03	0.00	0.03

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Human Development Index (HDI) by country 2024 (2024)

The results of the analysis show that the GERD indicator has a statistically significant impact on the level of human development ($p = 0.002$). Accordingly, such an impact can be tracked already at the stage of short-term analysis. Results of regression analysis of the impact of investment in innovation on GDP per hours worked are shown in Table 7.

Table 7. Regression analysis results for a sample of countries for a single period, dependent variable – GDP per hours worked

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	80.87	14.49	5.58	0	51.15	110.6	51.15	110.6
GERD, % of DGP	−1.22	6.02	−0.2	0.84	−13.56	11.12	−13.56	11.12

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Most productive countries (2024)

As in the case when the dependent variable was GDP per capita, this model does not show high explanatory ability. The impact of GERD on GDP per hours worked is not statistically significant, but the *p* values for Intercept suggest the existence of influential variables that are not represented in the model. Thus, in the short term, investment in innovation has the greatest impact on the human development indicator. To analyse the long-term impact of investment in innovation on the performance indicators of a knowledge-based economy, indicators for one region – EU countries – over a ten-year period of time were used. The results of correlation analysis for this sample are presented in Table 8.

Table 8. Results of correlation analysis for EU countries over a ten-year period

	GERD, % of DGP	GDP per capita	HDI (average)	GDP per hours worked
GERD, % of DGP	1			
GDP per capita	0.794888	1		
HDI (average)	0.851443	0.898074	1	
GDP per hours worked 2022	0.853218	0.954637	0.981321	1

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), GDP per capita (current US$) (2024), Most productive countries (2024), Human Development Index (HDI) by country 2024 (2024)

All the indicators under study are closely correlated with each other. This may indicate a significant long-term relationship between investment in innovation and the performance indicators of a knowledge-based economy. These results should be supplemented using regression analysis (Tables 9-11).

Table 9. Results of regression analysis for EU countries over a ten-year period, dependent variable – GDP per capita

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	28,724.33	5,660.31	5.07	0	15,671.63	41,777.03	15,671.63	41,777.03
GERD, % of DGP	11,098.48	2,995.21	3.71	0.01	4,191.51	18,005.45	4,191.51	18,005.45

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), GDP per capita (current US$) (2024)

The observed model has a significant explanatory capacity, since changes in GDP per capita by about 58% are explained by changes in GERD (as evidenced by the coefficient of determination). The effect of GERD on GDP per capita is significant, because $p = 0.01$. Thus, in the long run, investment in innovation significantly affects the GDP per capita indicator, and therefore, the well-being of the population. Table 10 contains the results of regression analysis for EU countries over a ten-year period using an indicator as a dependent variable HDI (average value).

Table 10. Results of regression analysis for EU countries over a ten-year period, dependent variable – HDI (average)

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	0.84	0.01	94.06	0	0.82	0.86	0.82	0.86
GERD, % of DGP	0.02	0	4.59	0	0.01	0.03	0.01	0.03

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Human Development Index (HDI) by country 2024 (2024)

This model also has a high explanatory capacity – approximately 69.1%. Impact of GERD on HDI (average) is statistically significant, as is the influence of Intercept, and therefore, the influence of other variables on the dependent indicator is not excluded. Table 11 shows the results of regression analysis for EU countries over a ten-year period using the GDP per hours worked indicator as an independent variable.

Table 11. Results of regression analysis for EU countries over a ten-year period, dependent variable – GDP per hours worked

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	41.03	3.73	11	0	32.44	49.63	32.44	49.63
GERD, % of DGP	9.13	1.97	4.63	0	4.58	13.68	4.58	13.68

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Most productive countries (2024)

The high explanatory capacity of this model is indicated by an updated coefficient of determination equal to 0.69. A statistically significant effect on GDP per hours worked is observed by both GERD and intercept. In general, all regression models for EU countries built to characterise the long-term impact of investment in innovation on economic efficiency have demonstrated high explanatory capacity and significant impact of GERD on other variables.

The inclusion of different approaches to correlation regression analysis allowed evaluating two prospects – short-term and long-term. Analysis of a sample of countries over a single period showed that the impact of GERD on some performance indicators of a knowledge-based economy may be weak at some stage, given the diversity of the economies under study. Accordingly, it can be assumed that in the short term, GERD is not a key factor in economic efficiency. An analysis of EU indicators over a ten-year period showed that in the long term, GERD significantly affects economic efficiency, and therefore, investment in innovation can have a cumulative effect, the consequences of which are manifested over time.

Special attention should be paid to the relationship identified between GERD and HDI, after all, a significant impact GERD on the latter indicator was observed both in the short and long term. This demonstrates the critical role of investment in innovation in human development, which is that investment in innovation often involves spending on science and education (Fernández-Villarán & Cuenca, 2023). This directly affects the improvement of access to knowledge and the well-being of the population. Investment in innovation is accompanied by technological development, which contributes to better working conditions, greater educational opportunities, and economic development in general (Ketners & Petersone, 2021). In the process of correlation analysis for both approaches, it was confirmed that the growth of HDI is associated with both increased productivity and GDP per capita growth. However, unlike GDP per capita, the HDI indicator considers longer trends and is not significantly affected by short-term fluctuations. It is more stable, which explains the close relationship between HDI and GERD in the short and long term.

Correlation and regression analysis based on data from Kosovo

One of the key results of the analysis is that investment in innovation can have a positive impact on the level of human development, labour productivity, and well-being in the long term. The impact on the level of human development was also observed in the short term. However, this analysis was mainly focused on the indicators of advanced countries. Therefore, it is worth checking the conclusions obtained from data from less developed countries, in particular, on the example of Kosovo. A comparison of Kosovo's indicators with those of EU countries is shown in Table 12.

As can be seen from Table 12, Kosovo lags far behind EU countries in terms of all the indicators mentioned. This highlights the need for an additional phase of analysis for Kosovo, which will help to understand the relationship between the indicators studied for less developed countries. The results of the correlation analysis between Kosovo's indicators are presented in Table 13.

Table 12. Comparison of average indicators of EU countries and Kosovo

	GERD, % of GDP	GDP per capita	HDI
EU	1.88	49,612.4	0.8818
Kosovo	0.79*	4,257	0.7507

Note: *average for the Balkan countries
Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), GDP per capita (current US$) (2024), Human Development Index (HDI) by country 2024 (2024), Kosovo GDP per capita 2008-2024 (2024), Subnational HDI (v8.1) (2024)

Table 13. Results of correlation analysis for indicators of Kosovo

	GERD, % of GDP (average for Balkans)	HDI	GDP per capita
GERD, % of GDP (average for Balkans)	1		
HDI	−0.70515	1	
GDP per capita	−0.52329	0.792085	1

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Kosovo GDP per capita 2008-2024 (2024), Subnational HDI (v8.1) (2024)

In the example of Kosovo, there was a significant negative correlation between GERD, % of GDP, and HDI and GDP per capita indicators. This may indicate a low efficiency of investment in innovation. It can also be assumed that Kosovo may need more time to achieve a positive long-term investment effect. In addition, a strong positive relationship was found between HDI and GDP per capita. This may indicate that the level of human development in Kosovo contributes to the improvement of the overall well-being, but this is not through innovation, but through other sectors of the economy. Table 14 contains the results of regression analysis of GERD effects, where the dependent indicator is HDI.

Table 14. Results of regression analysis based on data from Kosovo, dependent variable – HDI

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	0.76	0.01	141.24	0	0.75	0.77	0.75	0.77
GERD, % of GDP (Average for Balkans)	−0.01	0	−3.30	0.01	−0.02	0	−0.02	0

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Subnational HDI (v8.1) (2024)

The analysis confirmed the presence of a negative relationship between GERD and HDI for Kosovo. The detected effect is statistically significant for both GERD and Intercept, but the effect of Intercept is direct. This may indicate that the level of human development in Kosovo is positively affected by indicators not considered in the study. Table 15 contains the results of regression analysis, where GDP per capita acts as a dependent variable.

Table 15. Results of regression analysis based on Kosovo data, dependent variable – GDP per capita

	Coefficients	Standard error	*t* stat	*p* value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	4,554.47	305.43	14.91	0	3,882.23	5,226.71	3,882.23	5,226.71
GERD, % of GDP (Average for Balkans)	−509.38	250.1	−2.04	0.07	−1,059.85	41.09	−1,059.85	41.09

Source: calculated by the authors based on Leading countries by research and development (R&D) expenditure as share of gross domestic product (GDP) worldwide in 2022 (2024), Kosovo GDP per capita 2008-2024 (2024)

In this case, the impact GERD is also negative, but less statistically significant ($p < 0.1$). Instead, the influence of Intercept is direct and statistically significant, which, as in the previous model, may indicate the presence of other influential variables. Thus, the assumption of low efficiency of investment in innovation in Kosovo was confirmed, as supported by information from the report, which should be a signal for government officials to review existing policies in the investment and innovation sectors (Kosovo 2024 report, 2024). The results of the analysis for Kosovo differ significantly from the results for EU countries. It was found that GERD in the country is inversely correlated with HDI and GDP per capita indicators. Differences in results for Kosovo and leading countries indicate the feasibility of using world practice in state initiatives. The development of appropriate strategies should consider that investment in innovation may not have an immediate effect, and it takes a longer period of time to achieve positive results.

Knowledge is an essential requirement for the economic growth of any country in the world (Pons Vives *et al.*, 2022) and knowledge-based capital is a source of innovation and contributes to productivity growth (Zakharchyn & Sytnyk, 2023). Based on innovations and technologies, the movement towards the development and progress of states is accelerating. Knowledge-based capital covers a variety of intangible assets, including R&D, data sets, software, etc. (Ismayil-Zada, 2023). The rapid development of technology in the knowledge economy is leading to an

increasing focus on investing in knowledge-based capital. The conclusions of the study regarding the leading role of human capital in a knowledge-based economy coincide with the opinion of B.C. Olopade *et al*. (2020), R. Rohimah (2021) and S.K. Singh *et al*. (2021). The researchers have noted that people's knowledge and skills and human development are key factors for achieving sustainable and innovative development. Z.T. Bimagambetova *et al*. (2023) identified the level of human development as a process of increasing human opportunities through improving health and education, longevity, gaining broader political and economic freedoms, ensuring human rights and respect for the individual. The researcher considered the level of human development to be the main factor in the transition to a knowledge-based economy. In addition, B.H. Mohamed *et al*. (2021) found that factors influencing human development can vary significantly across countries and regions, which was confirmed in this paper by comparing the results of the analysis for the EU countries and Kosovo. Moreover, I. Bąk *et al*. (2022) proved that even within the EU, the level of development of the knowledge economy based on people's knowledge and skills varies significantly in different regions, which significantly affects the innovation capabilities of countries. Similar conclusions were reached by C.F. Albu *et al*. (2020), who noted that such differences are conditioned by the fact that some countries do not invest enough in innovation, R&D.

The next key conclusion from the paper is to identify the fact that investment in innovation can have different impacts on HDI and other indicators studied in the short and long term. J. Hao *et al*. (2020) concluded that a lower intensity of investment in R&D has a positive effect on short-term results, and an increase in this intensity reflects well on the long-term effectiveness of innovation. These conclusions can serve as a confirmation of the thesis of this paper regarding the cumulative effect of investment in innovation. Another study that focused on the differences in short- and long-term results of investment in innovation was conducted by T.Y. Leung & P. Sharma (2021). The researchers have shown that the intensity of R&D can have a negative impact on short-term financial indicators, but they have a positive impact on long-term indicators. This may indicate the validity of the findings of this paper that Kosovo needs a longer period to demonstrate the positive impact of investment in innovation. Now, as noted in the paper, investment in innovation in Kosovo has an inverse relationship with the level of human development and GDP per capita.

In this paper, some additional conclusions were also drawn about the mutual relationship of the indicators under study. In particular, it was noted that investment in innovation has a long-term positive impact on productivity. In contrast to these conclusions, D.B. Audretsch & M. Belitski (2020) proved that R&D are less important for productivity than knowledge dissemination. In addition, the paper revealed a positive relationship between the level of human development, well-being and productivity. These conclusions were confirmed by H. Ostrovska *et al*. (2020), which substantiated the link between well-being, health, intellectual potential, innovation, and economic growth. In addition, such results were reflected in the study by T. Gulcemal (2020), who noted that human development contributes to economic growth by analysing the HDI and GDP indicators of a number of developing countries. R. Dědeček & V. Dudzich (2022) identified the shortcomings of using such an indicator as GDP per capita as an indicator of economic development and well-being. The results of the study showed that countries with higher income inequality may be characterised by a lower level of development than their GDP per capita indicator suggests. In this paper, the HDI indicator was also used as an indicator of the level of development, and therefore, the conclusions of researchers can be relevant in the context of this study, which also revealed that GDP per capita is not stable enough for an accurate assessment of economic development. Thus, the conclusions of the study correlate with the conclusions of other studies. In addition, the results of this paper provide a new vision of the relationship between investment in innovation and the level of human development, productivity, and GDP per capita through an in-depth analysis of the impact of investment in innovation in the short and long term.

CONCLUSIONS

The results showed an increased focus on investment in innovation at the global level. As of 2022, global innovation spending totalled USD 2,475.7 billion. Leading countries such as the US, EU countries, China, and Japan are increasingly investing in R&D. Their share in global R&D spending is more than 70% in the aerospace and defence industries, automotive, energy, finance, and other industries. This allows them to maintain their competitiveness in the international arena. Based on the results of a regression analysis conducted on the data of these countries to identify the short-term impact of GERD on HDI, productivity, and GDP per capita, a statistically significant impact at the level of $p = 0.002$ was recorded only on the human development indicator. The results of the regression analysis for EU countries, which included an assessment of the long-term impact of GERD, showed a statistically significant ($p < 0.05$) effect on all dependent indicators. Consequently, investment in innovation has a cumulative effect that manifests itself over time. The identified impact of GERD on HDI in the short and long term suggests that investment in innovation plays a key role in human capital development. In turn, human capital development is a more stable, sustainable, and indicative predictor of economic growth than other indicators under study, such as GDP per capita, reflecting longer-term trends.

Along with analysing data from the world's leading countries, the study included regression analysis based on data from Kosovo. This analysis showed the long-term impact of investment in innovation on the country, although given the limited data for Kosovo, the analysis did not include a national GERD indicator, but the average GERD indicator for the Balkan countries. This is a limitation of the study, because it can slightly distort the results due to the combination of national indicators with a regional indicator. Regression analysis of Kosovo data revealed an inverse relationship between the average GERD and indicators of GDP per capita and the level of human development. The regression coefficients were −509.38 and −0.01 at significance levels $p = 0.07$ and $p = 0.01$, respectively. Such results of the analysis show the low efficiency of investment in innovation in Kosovo, which should be a signal for officials

to reconsider the existing policy in the investment, innovation and education spheres. Kosovo may need a much longer period of time to achieve the positive effect of investment in innovation compared to advanced countries, which is conditioned by the cumulative effect of such investments. This may indicate the need to reorient development policies from short-term goals to more sustainable and long-term ones. Future studies should include a wider range of additional indicators for in-depth analysis of their impact on economic efficiency, such as indicators of investment in education, considering short-and long-term prospects.

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CONFLICT OF INTEREST

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Економічна ефективність інвестицій в інновації в економіці, заснованій на знаннях

Анотація. Метою дослідження було проаналізувати вплив валових внутрішніх витрат на дослідження та розробки на ключові показники ефективності економіки, заснованої на знаннях, у короткостроковій та довгостроковій перспективі, використовуючи дані розвинених країн та країн, що розвиваються. Результати дослідження засвідчили зростання уваги до інвестицій в інновації у глобальному вимірі. Провідними країнами та регіонами за обсягами інвестицій в інновації є Сполучені Штати Америки, Європейський Союз, Китай та Японія. Регресійний аналіз короткострокового впливу валових внутрішніх витрат на дослідження та розробки на ключові показники економічної ефективності (рівень людського розвитку, продуктивність праці та валовий внутрішній продукт (ВВП) на душу населення) виявив статистично значущий вплив лише на показник рівня людського розвитку. Але аналіз довгострокового впливу цього показника на прикладі даних країн Європейського Союзу виявив статистичну значущість цього впливу на всі залежні змінні. Це довело, що інвестиції в інновації мають кумулятивний ефект, який проявляється в довгостроковій перспективі. Виявлений вплив на показник рівня людського розвитку як у короткостроковій, так і в довгостроковій перспективі свідчить про фундаментальну роль інвестицій в інновації у такому розвитку. Аналіз даних по Косово виявив зворотну кореляцію між валовими внутрішніми витратами на дослідження і розробки та ВВП на душу населення і людським розвитком. Це свідчить про низьку ефективність інвестицій в інновації в країні та припускає, що Косово може знадобитися більше часу для досягнення позитивного кумулятивного ефекту від інвестицій. Відповідно, уряд Косова повинен спиратися на успішний міжнародний досвід розвинених країн у розробці інноваційно-інвестиційних ініціатив та налагодженні міжнародного співробітництва. Крім того, інвестиції в інновації можуть не мати негайного позитивного ефекту, і для його досягнення потрібно більше часу

Ключові слова: валові внутрішні витрати на дослідження і розробки; індекс людського розвитку; продуктивність; валовий внутрішній продукт на душу населення; кумулятивний ефект; короткострокова і довгострокова перспектива; рівень розвитку