Regional Disparities in R&D and Innovation Expenditures: A Comparison between the Bratislava Region and Other Slovak Regions

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Abstract: This paper examines regional disparities in research and innovation (R&D) expenditures across Slovakia, with particular emphasis on differences between the Bratislava Region and the remaining NUTS 2 regions. The aim of the study is to identify the extent of these disparities and to assess whether they are statistically significant. The analysis is based on secondary data obtained from the Regional Innovation Scoreboard (RIS) 2023, compiled by the European Commission in cooperation with Maastricht University. Using descriptive statistics and inferential analysis, including independent samples t-tests, the study compares public and private R&D expenditures as a percentage of GDP across Slovak regions. The results reveal that the Bratislava Region significantly outperforms other regions in both public and private R&D investment, confirming the presence of pronounced regional disparities in innovation financing. These findings highlight the need for targeted, region-specific innovation policies aimed at strengthening R&D capacity in less developed regions and supporting more balanced regional development in Slovakia.

Keywords: regional disparities, research and development, innovation expenditure, Regional Innovation Scoreboard, Slovakia
JEL Classification: R11, O31, O32

1 Introduction

Innovation is widely recognized as a key driver of economic growth, productivity, and regional competitiveness. In the context of the European Union's efforts to reduce regional disparities, the promotion of research and innovation (R&I) has become a central pillar of cohesion policy. Despite significant investments, however, innovation performance remains highly uneven not only between countries but also within them. Slovakia represents a striking example of this intra-national divide, with the Bratislava region consistently outperforming the rest of the country in R&D spending and innovation capacity.

The Bratislava region, classified as a "strong innovator" by the Regional Innovation Scoreboard (RIS) 2023, demonstrates markedly higher levels of both public and private sector R&D expenditures compared to other Slovak NUTS 2 regions (Western, Central, and Eastern Slovakia). These disparities raise important questions about the underlying drivers of regional innovation capacity, including institutional quality, human capital, industrial structure, and the effectiveness of regional policy instruments.

This paper aims to investigate the extent and nature of regional disparities in research and innovation expenditures in Slovakia. By comparing the Bratislava region with other NUTS 2 regions, the study seeks to identify the key structural and policy-related factors contributing to the observed gap. The analysis is based on data from RIS 2023 and employs both descriptive and inferential statistical methods. The findings are intended to inform more effective and region-sensitive

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innovation policies that can support balanced development and enhance the overall absorptive capacity of Slovakia's innovation ecosystem.

Understanding the territorial dynamics of R&D investment is essential for designing targeted interventions that address specific regional needs. While national innovation strategies often adopt a one-size-fits-all approach, regional disparities in absorptive capacity, institutional infrastructure, and knowledge spillovers require more nuanced solutions. By contextualizing Slovakia's regional innovation performance within broader European trends and theoretical frameworks—such as regional innovation systems and spatial inequality. This study contributes to the growing body of literature advocating for place-based innovation policies. Ultimately, reducing the innovation gap between the capital and the periphery is not only a matter of equity but a strategic imperative for achieving sustainable and inclusive economic growth.

2 Literature Review

Regional development and innovation performance are closely interlinked, with innovation serving as a key driver of economic growth and competitiveness. The relationship between these two factors is complex and influenced by a variety of determinants, including resource allocation, policy support, and socio-economic conditions. This synthesis examines the multifaceted nature of innovation performance across regions and highlights key factors that contribute to or hinder regional development. Innovation performance is a key prerequisite for the long-term competitiveness and economic growth of enterprises and regions. As Rubera and Kirca (2012) point out, companies that actively innovate are more likely to achieve sustainable growth and global competitiveness. According to Ivanová and Masárová (2019), the current state of innovation systems in EU countries shows significant disparities, with the intensity of research and development (R&D) expenditure and the absorptive capacity of regions being the main factors contributing to regional inequalities.

Several studies emphasize that the development of innovation capacities is influenced by the concentration of human capital, research infrastructure, and international cooperation, which gives metropolitan regions a natural advantage. Iammarino et al. (2020) stress that urban areas benefit from synergies between capital, knowledge, and technological platforms, while peripheral regions face problems such as low absorptive capacity, limited cooperation between universities and firms, and weak public innovation support. The importance of financial resources as a main condition for innovation development is also confirmed by Lesáková et al. (2017), who, based on a survey of Slovak SMEs, identified financial constraints, weak cooperation with research institutions, and bureaucratic barriers as the most common obstacles to innovation activity. The authors distinguish between innovation leaders, modest innovators, and non-innovative firms, emphasizing the need for targeted public support, the development of regional clusters, and networking.

Another important dimension is the regional and spatial context of innovation. Borseková et al. (2017) highlight the significance of smart specialization and local potential as tools to enhance regional competitiveness. According to the authors, the effective use of endogenous resources and strategic coordination among institutions lead to the sustainable development of innovation ecosystems. From a regional perspective, Rentková and Gejdoš (2019) provide a detailed view of the impact of small and medium-sized enterprises on the economic performance of Slovak regions. Their research points to a close link between GDP growth, unemployment reduction, and entrepreneurial activity, with SME innovation representing one of the most important sources of regional growth. Visegrad Group regions show substantial disparities in innovation performance, particularly in public-private co-publications and SME collaboration, underlining the importance of tailored innovation strategies that address specific regional needs (Ivanová & Masárová, 2019). Spatial analysis across EU regions indicates that regional innovativeness and economic performance are significantly affected by geographic location and neighbouring regions. Social capital effects and competition between internal R&D and external technology acquisition play a decisive role in regional economic outcomes (Olejnik & Żółtaszek, 2020). In Portugal's Alto Minho region, progress toward Sustainable Development Goal 9 (industry, innovation, and infrastructure) varies significantly between municipalities, suggesting the need for targeted policy interventions to promote balanced regional development (Abreu et al., 2023). Policy support and cultural values also moderate the relationship between innovation input and performance. In China, policy support enhances innovation outcomes, while cultural dimensions such as egalitarianism and mastery positively influence innovation input efficiency. The effectiveness of R&D support depends on the existing level of innovation activity, with below-average R&D regions benefiting most from targeted interventions. While innovation is a key driver of regional development, the effectiveness of innovation strategies varies significantly across regions due to differences in resource utilization, political environments, and socio-economic contexts (Lesáková et.al, 2017).

Regions with strong policy support and effective resource management tend to exhibit better innovation performance. However, disparities in innovation outcomes underscore the need for region-specific strategies that reflect local characteristics and potential. Understanding this dynamic is crucial for policymakers aiming to foster sustainable regional development through innovation. Regional disparities in R&D and innovation expenditures are a complex phenomenon

shaped by the capacity of innovation systems, institutional environments, and the economic performance of regions. R&D is considered a dominant driver of regional growth and competitiveness (Capello & Lenzi, 2016). Disparities between more and less developed regions (e.g., the Bratislava region vs. peripheral areas) are largely conditioned by industrial structure diversity, human capital absorption capacity, and geographic clusters (Boschma, 2004; Frenken et al., 2007). Mature agglomerations and knowledge networks foster regional spillovers, whereas their absence hinders the development of peripheral regions (Schergnell & Barber, 2010;). Institutional development theory emphasizes the necessity of stable formal institutions and coordination mechanisms for the growth of regional innovation systems. Less developed regions often suffer from weak integration of intellectual capacities and insufficient policy support (Ayuso S. et al, 2011). Capital cities and metropolitan areas such as Bratislava are among the so-called "smart urban regions," characterized by high concentrations of capital, talent, and social interaction that support innovation growth (Iammarino et al., 2020). In contrast, less developed regions often fall into the "middle-income trap," where short-term firm-level innovations are insufficient for sustained economic growth (Iammarino et al., 2020).

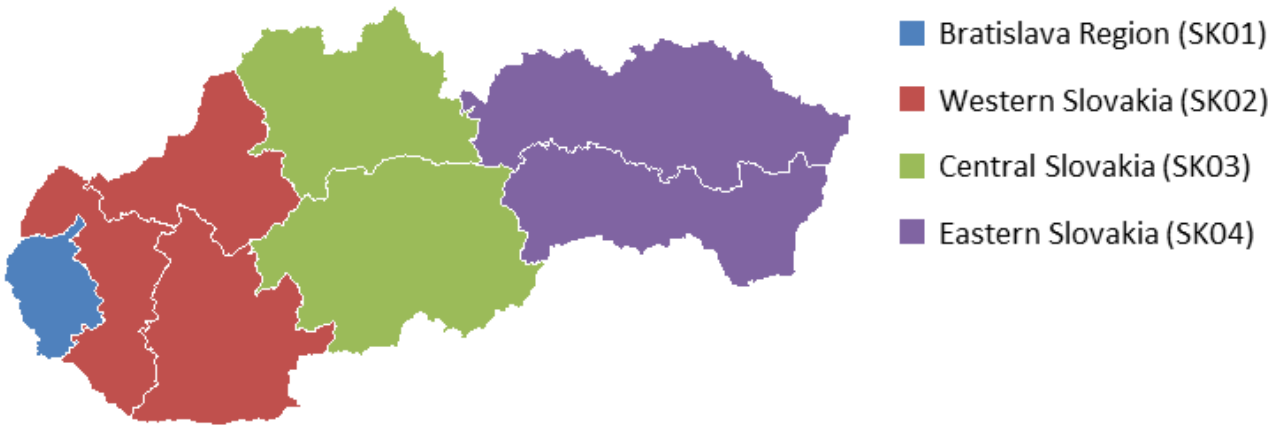
R&D and innovation expenditures are typically measured using composite indices such as the Regional Innovation Scoreboard (RIS), which aggregates public and private investment, patent activity, academic output, and technology transfers (European Commission, 2023). Studies on innovation convergence show that R&D investments in urban centers converge more rapidly than in peripheral areas, contributing to regional stratification. These findings confirm that geographic and cognitive proximity increase the likelihood of sustained cooperation (Scherngell & Barber, 2010).

In summary, the theoretical framework builds on an integrated understanding of innovation systems, institutions, geographic clusters, and their interactions as key determinants of the regionalization of R&D investment. This framework supports the hypothesis that the Bratislava region exhibits higher R&D spending as a result of its strong absorptive capacity, robust intellectual ecosystem, and favorable institutional background.

3 Methods

This study adopts a quantitative research design based on secondary data analysis. The data were obtained from the *Regional Innovation Scoreboard (RIS) 2023 – Regional Profiles: Slovakia*, published by the European Commission in cooperation with Maastricht University (UNU-MERIT). The RIS provides harmonized and comparable indicators of regional innovation performance across European Union regions at the NUTS 2 level.

This study employs a quantitative research design and utilizes secondary data analysis to examine regional disparities in research and innovation expenditures between the Bratislava Region (SK01) and the other NUTS 2 regions of Slovakia. The primary objective is to assess whether significant differences exist in public and private R&D investment levels across these regions.



The data were obtained from the publication Regional Innovation Scoreboard 2025 – Regional Profiles Slovakia, published by the European Commission (Directorate-General for Research and Innovation) in cooperation with Maastricht University – UNU-MERIT. This source offers a comprehensive evaluation of regional innovation performance in Slovakia, based on data spanning the period 2018 to 2025, and structured according to the NUTS 2 classification.

The RIS assessment integrates multiple data sources, including the Community Innovation Survey (CIS), Eurostat, PCT patent statistics, and Scopus-indexed scientific publications. The analysis focuses on key indicators representing public and

private sector investments in research, development, and innovation (RDI). Statistical analyses were conducted using JAMOVI statistical software.

To assess the normality of selected variables, the Shapiro–Wilk test was applied prior to further inferential testing. Subsequently, independent samples t-tests were used to evaluate differences in R&D expenditures between the Bratislava Region and the aggregate of the remaining Slovak regions.

Selection of variables: The analysis concentrates on indicators capturing research and innovation expenditure, as these represent key input factors of regional innovation systems. Specifically, two indicators were selected from the RIS database; public sector R&D expenditure as a percentage of GDP, and business sector R&D expenditure as a percentage of GDP. These indicators were chosen for three main reasons. First, R&D expenditure is widely recognized in the literature as a primary determinant of innovation capacity and regional competitiveness. Second, both indicators are consistently available across Slovak regions and over time, ensuring comparability. Third, the distinction between public and private R&D investment allows for a more nuanced assessment of regional disparities and policy relevance, particularly in the context of capital versus peripheral regions.

Research Assumption was that it is assumed that the Bratislava Region exhibits significantly higher levels of R&D and innovation expenditure compared to other Slovak regions, both in the public and private sectors.

The main research question: *Are there statistically significant differences in research and innovation expenditure between the Bratislava region and other regions of Slovakia?*

Following the research question, two research hypotheses were established.

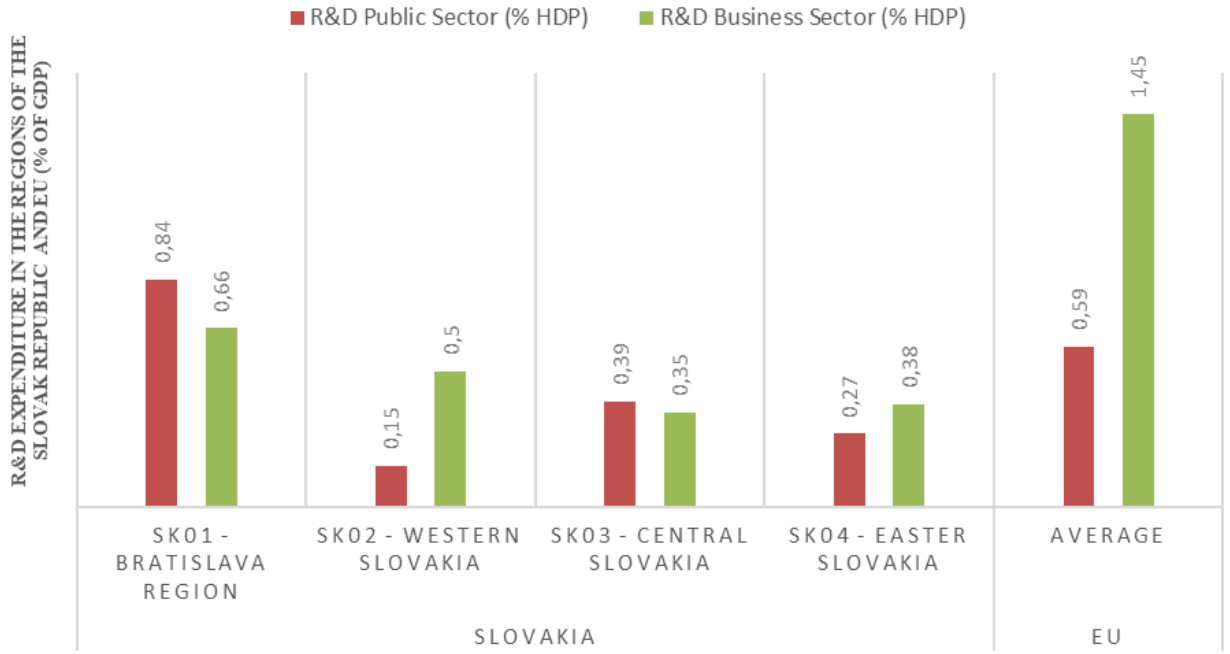
- ***H₀:*** There are no statistically significant differences in expenditure on research and innovation between the Bratislava region and other regions of Slovakia.
- ***H₁:*** There are statistically significant differences in expenditure on research and innovation between the Bratislava region and other regions of Slovakia.

4 Research results

Bratislava region and other regions of Slovakia. The aim of the analysis was to identify whether there are statistically significant differences in the level of public and private investment in research and development (R&D), with particular attention paid to comparison with the European Union average. Based on data from the *Regional Innovation Scoreboard 2023*, descriptive and inferential statistics were performed to assess regional disparities in the financing of innovation activities. The tables and graphs in this chapter show the differences between individual regions of Slovakia, as well as the position of the Bratislava region in relation to the EU average. The results of statistical tests then provide an answer to the research question and allow the hypotheses to be evaluated.

Table 1 shows public and private expenditure on research and innovation in individual regions of Slovakia for 2023. The values represent the share of public and business sector expenditure on research and development (R&D) as a percentage of gross domestic product (GDP). The highest share of public and private investment is in the Bratislava region (0.84% and 0.66% of GDP), while other regions (Western, Central, and Eastern Slovakia) show lower values. The data point to significant regional differences in support for innovation activities at the regional level. Chart 1 visually illustrates public and private expenditure on research and innovation in Slovakia's regions in 2023. The bar chart allows for a comparison of investment intensity between regions. The Bratislava region significantly outperforms other regions, especially in terms of public expenditure. This graph clearly illustrates the concentration of innovation activities and investments in the capital city and its surroundings.

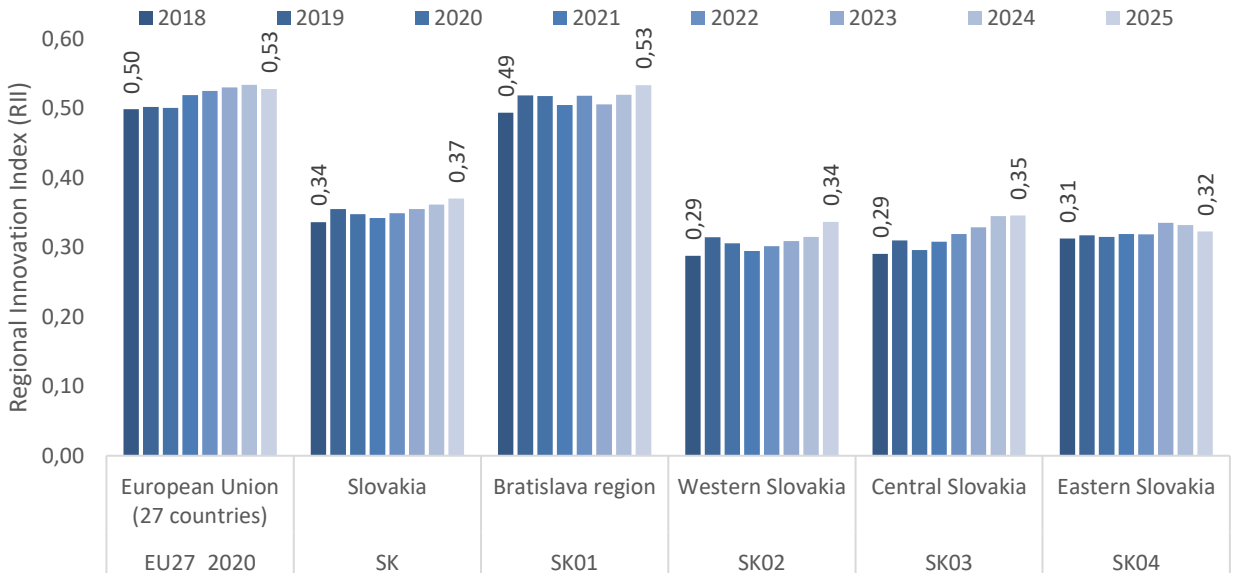
Figure 1 Visual representation of expenditure on research and innovation in Slovak regions with the EU average for 2023



Source: Own processing based on European Commission

This figure 1 presents the development of the Regional Innovation Index (RII) for Slovakia (SK) and its NUTS 2 regions—Bratislava Region (SK01), Western Slovakia (SK02), Central Slovakia (SK03), and Eastern Slovakia (SK04)—in comparison to the EU27 average between 2018 and 2025. The values range from 0.29 to 0.53, indicating notable disparities in regional innovation performance. The Bratislava Region (SK01) consistently shows the highest RII values among Slovak regions, growing from 0.49 in 2018 to 0.53 in 2025, closely aligning with the EU27 average. In contrast, the other Slovak regions remain significantly below both the national and European averages, with only moderate increases over the observed period. The national average for Slovakia (SK) improves from 0.34 to 0.37, reflecting slow but steady progress. These results highlight the persistent innovation gap between the capital region and the rest of the country, emphasizing the need for targeted innovation policies to strengthen regional capacities.

Figure 2 Regional Innovation Index (RII) for Slovakia and Its NUTS 2 Regions Compared to the EU Average, 2018–2025

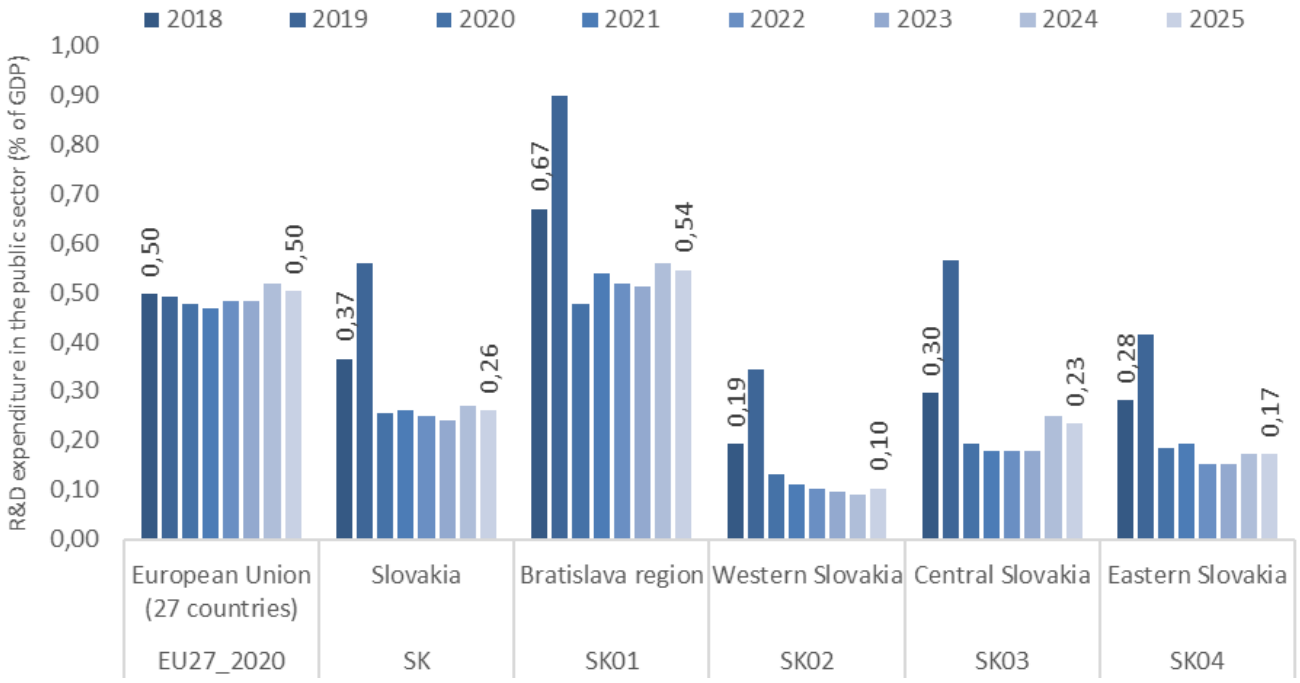


Source: Own processing based on Eurostat

The figure 2 presents the annual evolution of R&D expenditure in the public sector as a percentage of GDP for the European Union (EU27), Slovakia (national average), and its four NUTS 2 regions from 2018 to 2025.

The data reveal substantial disparities across Slovak regions: The Bratislava Region (SK01) consistently reports the highest public R&D spending, peaking at 0.90% in 2019, and stabilizing around 0.54% by 2025. In contrast, Western Slovakia (SK02) shows the lowest investment levels, declining from 0.34% in 2019 to only 0.10% in 2025. Central (SK03) and Eastern Slovakia (SK04) show modest and stable levels, with slight increases post-2023, reaching 0.23% and 0.17%, respectively. The national average for Slovakia fluctuates between 0.24% and 0.56%, with a noticeable decline after 2019. Compared to the EU27 average (which remains around 0.48–0.52%), only the Bratislava Region surpasses the European benchmark, underscoring the strong regional imbalance in public R&D investment. These findings highlight the capital region's dominant role in public research funding, while peripheral regions lag significantly behind, suggesting a need for policy interventions to support more balanced R&D development.

Figure 3 Public Sector R&D Expenditure (% of GDP) in Slovakia and Its NUTS 2 Regions Compared to the EU Average, 2018–2025

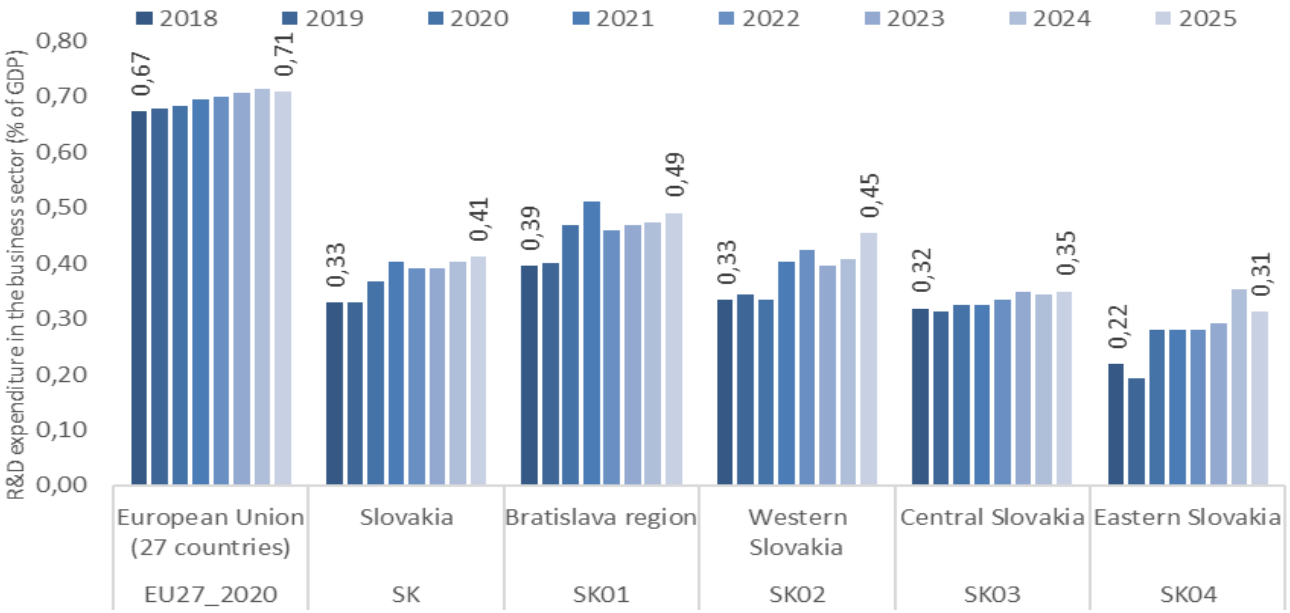


Source: Own processing based on Eurostat

Figure 3 displays the evolution of R&D expenditure in the business sector as a percentage of GDP from 2018 to 2025, comparing Slovakia's national average and its NUTS 2 regions (Bratislava Region – SK01, Western Slovakia – SK02, Central Slovakia – SK03, and Eastern Slovakia – SK04) to the EU27 average. The EU27 average shows a steady increase from 0.67% in 2018 to 0.71% in 2025, while Slovakia's national average rises from 0.33% to 0.41%, remaining below the EU benchmark throughout the period.

Among Slovak regions Bratislava Region (SK01) consistently leads in business R&D investment, growing from 0.39% in 2018 to 0.49% in 2025, peaking at 0.51% in 2021. Western Slovakia (SK02) shows significant improvement, rising from 0.33% to 0.45%, closing the gap with Bratislava. Central Slovakia (SK03) remains relatively stable with slight growth, ending at 0.35%. Eastern Slovakia (SK04) has the lowest figures overall but improves from 0.22% in 2018 to 0.31% in 2025. These trends reflect persistent regional disparities in private R&D investment, but also signal some convergence between the capital and other regions, particularly Western Slovakia.

Figure 4 Public Sector R&D Expenditure (% of GDP) in Slovakia and Its NUTS 2 Regions Compared to the EU Average, 2018–2025



Source: Own processing based on Eurostat

Figure 4 Results of statistical analysis

Independent Samples T-Test				
		Statistic	**df**	**p**
Value	**Student's t**	4.17	6.00	0.006
Note. H_a $\mu_{Bratislavský\ kraj} \neq \mu_{Ostatné\ regióny}$				

Group Descriptives						
	Group	**N**	**Mean**	**Median**	**SD**	**SE**
Value	**Bratislava region**	2	0.750	0.750	0.127	0.0900
	Other regions	6	0.340	0.365	0.119	0.0486

Source: Own processing in the program JAMOVI based on the document https://ec.europa.eu/asets/rtd/ris/2023/ec_rtd_ris-regional-profiles-slovakia.pdf

Figure 4 extends the previous comparison with the European Union (EU) average benchmark. In addition to Slovak regions, it also includes average values for public (0.59% of GDP) and private (1.45% of GDP) expenditure on research and innovation in EU countries. The data show that the Bratislava region exceeds the EU average in public expenditure but lags significantly behind in private investment. Other Slovak regions lag behind the EU average in both sectors. The bar chart shows a significant difference between the Bratislava region and the rest of Slovakia, as well as between Slovak regions and the EU average, with the largest difference being in private investment. This chart highlights the need to stimulate private spending on research and innovation outside the capital.

Table 1 presents the results of statistical analysis performed in the JAMOVI program. The parametric t-test ($t(6) = 4.17$, $p = 0.006$) showed a statistically significant difference in research and innovation expenditure between the Bratislava region and other regions of Slovakia. Descriptive statistics show that the Bratislava region achieved an average value of 0.75% of GDP, while other regions achieved an average of only 0.34% of GDP. This result supports the alternative hypothesis of the existence of significant regional differences.

4 Discussion

The results of the analysis showed significant differences in research and innovation expenditure between the Bratislava region and other regions of Slovakia. Compared to Western, Central, and Eastern Slovakia, the Bratislava region shows significantly higher public (0.84% of GDP) and private (0.66% of GDP) investment in research and de-velopment. Statistical analysis confirmed these differences, with a parametric t-test indicating their statistical signifi-cance ($t(6) = 4.17$; $p = 0.006$). These findings are consistent with theoretical concepts about the concentration of in-novation activities in metropolitan areas. As noted Iammarino et al. (2020), urban regions bene-fit from the synergistic effects of high concentrations of human capital, financial resources, and innovation infra-structure that support the creation of knowledge and technology. Conversely, less developed regions often face ob-stacles such as a weak research base, low absorption capacity, and limited cooperation between universities and the business sector (Capello & Lenzi, 2016). Lesáková et al. (2017) further elaborate on these challenges by identifying financial constraints, insufficient public support, and bureaucratic hurdles as key barriers to innovation in Slovak SMEs, particularly outside of major urban centers. These obstacles were also evident in the lower R&D activity observed in Western, Central, and Eastern Slovakia in this study, emphasizing the systemic limitations facing less developed regions. The analysis confirms that geographic location and structural conditions remain decisive in shaping innovation outcomes, echoing the observations of Borseková et al. (2017), who advocate for smart specialization strategies and local coordination as tools for enhancing regional innovation ecosystems. The strong performance of the Bratislava region can thus be attributed to its role as a knowledge and capital hub, with high levels of institutional coordination, supporting the view that regional innovation policy must be place-sensitive and context-driven.

The results point to the need for systematic measures to support the development of innovation ecosystems in less developed regions. Key recommendations include promot-ing private investment through tax incentives and grant schemes, developing regional innovation clusters, and strengthening cooperation between research institutions and the business sector. In addition, it is important to tailor innovation policies to the specific characteristics of individual regions, as universal approaches have proven to be less effective (Ivanová & Masárová, 2019).

5 Conclusions

The aim of this paper was to examine regional disparities in research and innovation expenditures between the Bratislava Region (SK01) and the other NUTS 2 regions of Slovakia, based on data from the *Regional Innovation Scoreboard 2023*. The results demonstrate that the Bratislava Region consistently achieves significantly higher levels of both public and private investment in research and development (R&D), confirming its role as the dominant innovation hub in the country. In contrast, the remaining Slovak regions lag not only behind Bratislava but also fall short of the European Union (EU27) average, particularly in the area of business sector investment.

Statistical analysis supported these observations. An independent samples t-test conducted to compare average R&D expenditures revealed a statistically significant difference between Bratislava and the rest of Slovakia ($t(6) = 4.17$, $p = 0.006$). This result allowed us to reject the null hypothesis that no differences exist, and to accept the alternative hypothesis, which posits the presence of regional disparities in research and innovation funding. The statistical evidence therefore affirms that the Bratislava Region significantly outperforms other regions in both public and private R&D investment as a share of GDP.

These findings underline the urgent need for targeted regional policies aimed at strengthening innovation capacity in less developed areas of Slovakia. Key policy recommendations include stimulating private R&D investment in underperforming regions, fostering the development of regional innovation clusters, and enhancing collaboration between universities, research institutions, businesses, and public administration. Such measures would help address structural imbalances and support more inclusive and sustainable regional development.

At the same time, this research faces several limitations that should be acknowledged. First, the analysis relied solely on secondary data drawn from the RIS 2023 report, which limits the ability to verify the quality, motivations, or contextual specifics of the data sources. Second, the study is based on a fixed time frame (mainly reflecting 2023), which may not fully capture recent policy changes or investment dynamics. Third, the small sample size—limited to four Slovak regions—constrains the statistical power of the tests and restricts the generalizability of the results to broader contexts.

To address these limitations, future research should incorporate primary data collection, such as expert interviews or firm-level surveys, to gain deeper insight into the regional innovation landscape. Furthermore, qualitative analysis of institutional frameworks, innovation policy implementation, and business-sector engagement would enrich our

understanding of the mechanisms driving regional disparities in R&D performance. These steps are essential for designing more effective and evidence-based innovation strategies in Slovakia and similar regional contexts across Europe.

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