



Europe in the Global Economic System

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KNOWLEDGE, LEARNING AND CREATIVITY AS DETERMINANTS OF REGIONAL ECONOMIC DEVELOPMENT: THE CASE OF NUTS3 REGIONS OF THE CZECH REPUBLIC

Abstract

Knowledge, learning, and creativity represent key assets that enable the generation of new and original ideas and solutions, as well as the adoption of innovative approaches to existing ones. Through the combination of knowledge, learning, and creativity, both tangible and intangible outputs are created, whose synergistic effects make a significant contribution to regional development and the economic prosperity of society as a whole. The aim of this article is to identify the concentration of knowledge, learning, and creativity in the NUTS3 regions of the Czech Republic during the period 2010–2024 and to examine their transformation over the course of the observed period. The empirical analysis is based on Ward's hierarchical clustering method applied to a set of secondary data variables determining a "learning region." The concept of the learning region is particularly relevant because it encompasses and combines not only learning processes but also knowledge, science and research activities, and creativity. It is not surprising that the examined attributes are concentrated in the Capital City of Prague and the South Moravian Region. In contrast, the profiling of the remaining clusters, together

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with the identification of latent trends in their concentration over the 15-year period, provides valuable insights for further research as well as practical implications in terms of supporting the reduction of potentially undesirable disparities in access to this fundamental component of endogenous economic growth.

Key Words:

cluster analysis, Czech Republic, economic development, knowledge economy, learning concept, NUTS3 regions, regional competitiveness.

JEL: I20, O30, R12.

1 table, 2 figures, 58 references.

Problem Statement

The capacity for learning, the availability of knowledge, and the presence of creativity (or elements of science and research) predetermine the development potential of the areas in which they are concentrated, not only in the economic sphere but also in the social domain (Hartley et al., 2013; Weinstein & Clower, 2000; Turečková et al., 2023 or Mundelius, 2008). These attributes, firmly embedded in the concept of learning regions (see below), meet the requirements for stimulating endogenous growth, generate synergistic and externality effects, and are transformed into favorable outcomes and manifestations that shape our socio-economic environment (Florida, 2003; Borseková et al., 2021; Asheim, 1996; Boschma, 2005).

The purpose of this article is to identify the regions in the Czech Republic where these attributes are concentrated and to examine how the regions have evolved over the observed period. The Czech Republic comprises 14 NUTS3 regions, and relevant data were available for the period 2010–2024. It is generally acknowledged that the most prominent “learning region” in the Czech Republic is the Capital City of Prague, followed by the South Moravian Region. However, the subsequent ranking and interrelationships among the regions remain latent within the dataset, and their specification constitutes an innovative contribution of this study. A secondary objective is to characterize the resulting regional clusters within the framework of the learning region concept.

These findings are essential for further research aimed at testing the proposition that regions with a stronger learning orientation achieve higher levels of prosperity than those in which attributes associated with knowledge, skills, education, and creativity are less concentrated. It should be noted that the concept of learning regions is substantively comparable to the territorially defined notion of the “knowledge economy” (Lundvall, 1992; Morgan, 1997; Asheim, 2012; Cooke, 2001; Muzam, 2023; OECD, 2001, 2002).

The limitations of our research are primarily related to the availability of relevant data over an extended time horizon. On the other hand, the identification of trends represents an added value compared with the standard outputs typically provided by cluster analysis. No artificial intelligence tools were used in the preparation of the manuscript or in conducting the analysis, and, to the best of the authors' knowledge, an identical study has not previously been conducted either for the regions of the Czech Republic or for any other country.

Literature Review

Over the past decades, regional economics has undergone a significant transformation, with traditional production factors such as land, labor, and capital gradually receding in importance in favor of intangible resources based on knowledge, innovation, and human capabilities. The growing importance of knowledge has led to the emergence of the concept of the knowledge economy, in which the creation, distribution, and utilization of knowledge are regarded as the principal drivers of economic growth and competitiveness (Drucker, 1993; Cooke & Leydesdorff, 2006). Within this framework, knowledge assumes the role of strategic capital that contributes to value creation while simultaneously supporting the structural transformation of economies toward knowledge-based development.

Closely related to the development of the knowledge economy is the concept of the learning economy, formulated primarily by Lundvall & Johnson (1994). These authors argue that under conditions of rapid technological and societal change, it is not merely the quantity of available knowledge that matters, but above all the ability of individuals, organizations, and regions to continuously learn, adapt, and generate new knowledge. Learning thus ceases to be solely an individual process and becomes a crucial mechanism of economic development. The ability to learn more rapidly than competitors represents a significant source of long-term competitiveness for regions and economies (Lundvall & Johnson, 1994).

Building upon this argument, the concept of the learning region was further developed primarily by Florida (1995), Asheim (1996), and Morgan (1997). A learning region represents a spatial environment in which conditions are created for the production, sharing, and utilization of knowledge through intensive interactions among firms, educational institutions, research organizations, public authorities, and other regional actors. Morgan (1997) views the learning region as an institutionally embedded system of collective learning, whereas Asheim (1996) emphasizes the importance of regional networks and the transfer of tacit knowledge. Florida (1995), in turn, highlights that regional prosperity increasingly depends on the ability to create an environment that supports continuous processes of learning, innovation, and collaboration. The concept of the learning region therefore emphasizes the integration of knowledge, innovation, and education as a means of fostering regional development. This paradigm gained prominence in the context of globalization and the knowledge economy, underscoring the importance of continuous learning and adaptability in enhancing regional competitiveness (Iacobuta & Baci, 2009).

The importance of knowledge is also reflected in the structural transformation of economies and the growing significance of the quaternary sector. This sector

encompasses economic activities primarily based on the creation, processing, and dissemination of information and knowledge, particularly research and development, information technologies, education, consulting, and other knowledge-intensive services (Toffler, 1980; Kenessey, 1987). The development of the quaternary sector is widely regarded as one of the principal manifestations of the transition toward a knowledge economy, while its spatial concentration significantly influences regional competitiveness (Caragliu & Nijkamp, 2016; Turečková & Martinát, 2015). Regions with a higher share of knowledge-intensive activities generally exhibit greater productivity, stronger innovation performance, and a higher capacity to respond to economic change.

Alongside knowledge and learning processes, creativity represents the third key dimension of the learning region. Creativity is generally understood as the ability to generate new, original, and at the same time valuable ideas, solutions, or products (Boden, 1994). Andersson (1985) characterizes it as the capacity to combine knowledge, experience, and competencies in novel ways that lead to innovation. Although the concept of creativity itself is difficult to define and has been interpreted from various perspectives – psychological, sociological, technological, cultural, and economic (Barevičiūtė, 2014; Scott, 2000; Cherry & Latulipe, 2014; Baltrėnas et al., 2015; Pruskus, 2015) – most authors agree that it constitutes an important source of economic and social transformation.

From a regional-economic perspective, it is important to note that creativity is not an isolated phenomenon but emerges from accumulated knowledge and the capacity to learn. As Karlsson & Johansson (2012) argue, the source of creativity is always the individual who, through their knowledge, creates new combinations of information and generates innovative solutions. Kloudová (2009) points out that individual manifestations of creativity may exist independently; however, their most significant economic effects arise through their synergistic interaction with knowledge, innovation, and entrepreneurial activities. Creativity therefore represents the mechanism through which knowledge is transformed into economically valuable outputs.

The significance of this relationship is also highlighted by recent research focusing on the countries of Central and Eastern Europe, which identifies a close connection between educational activities, research performance, innovation, and the development of creativity as important components of the knowledge economy (Marczewska et al., 2024). Florida (2003) and Florida & Tinagli (2004) regard creativity as one of the primary productive resources of the contemporary economy. They refer to its carriers as the creative class, comprising scientists, researchers, engineers, IT specialists, architects, designers, artists, and other professional groups whose primary occupation involves the creation of new knowledge and ideas. Studies by Florida (2003), Mellander & Florida (2007), Florida et al. (2008) have demonstrated a positive relationship between the concentration of the creative class and the economic performance of regions. Recent research on European regions likewise confirms that regional creativity is closely associated with regions' capacity for learning, the quality of institutions, the development of innovation infrastructure, and the concentration of the creative class, while these factors simultaneously enhance regional innovation performance (Lishchynskyy et al., 2024). Creative environments also attract additional talented workers and investment, thereby generating a cumulative process that supports regional growth (Howkins, 2001; Mundelius, 2008).

It can therefore be concluded that knowledge, learning, and creativity constitute interconnected components of a single developmental system. Knowledge

forms the fundamental input, learning processes enable its creation, absorption, and dissemination, while creativity serves as the mechanism through which knowledge is transformed into innovation and economic value. The learning region thus represents an appropriate theoretical framework that integrates all three dimensions into a single analytical concept. Regions characterized by a well-developed knowledge infrastructure, a strong presence of the quaternary sector, and a high concentration of creative occupations demonstrate a greater capacity to generate innovation, foster endogenous economic growth, and strengthen their long-term competitiveness (Florida, 2003; Asheim, 1996; Morgan, 1997; Cooke, 1998).

Although an extensive body of literature has examined the knowledge economy, regional innovation systems, learning regions, and creativity separately, less attention has been devoted to their joint assessment within a regional context, particularly with regard to the analysis of their spatial concentration and evolution over time. This research gap is also evident in the case of the Czech Republic, where a comprehensive evaluation of the concentration of knowledge, learning, and creativity at the NUTS3 regional level over a longer time horizon is still lacking. Existing studies, where available, generally focus only on selected attributes and/or are already outdated. The present research seeks to address this gap.

Methodology

The aim of this article is to identify the concentration of knowledge, learning, and creativity in the NUTS3 regions of the Czech Republic during the period 2010–2024 and to examine their transformation over the course of the observed period. The description of the methodology logically follows from the formulation of this research objective.

The first step involved determining a set of indicators reflecting the examined attributes. The research was considerably constrained by the availability of relevant indicators over a sufficiently long time series and at the NUTS3 regional level. Ultimately, a set of ten indicators was constructed, which may be regarded as suitable, although in some cases indirect, proxies characterizing a learning region. These indicators are: (1) Share of the quaternary sector in the overall sectoral structure of the economy (in %); (2) Gross Value Added (GVA) of the quaternary sector (in million CZK); (3) Employees in the quaternary sector as a share of total employment (in %); (4) Share of gross fixed capital formation of the quaternary sector in total gross fixed capital formation (in %); (5) Share of economic entities in the quaternary sector among all economic entities (in %); (6) Share of the population aged 25–64 with tertiary education in the total population aged 25–64 (in %); (7) Expenditure on research and development (in million CZK); (8) Share of persons employed in research and development in the regional population (in %); (9) Research and development workplaces; and (10) Patents granted to applicants from the Czech Republic. Multidimensional Scaling was employed with regard to the nature of the input data, as some variables were expressed in absolute values while others were measured in relative units. The sources of the numerical data for these indicators were the Czech Statistical Office, Eurostat, and the Register of Economic Entities. The values of the selected indicators were collected for a fifteen-year period, from 2010 to 2024⁴. The complete input dataset used for the subsequent analysis is available

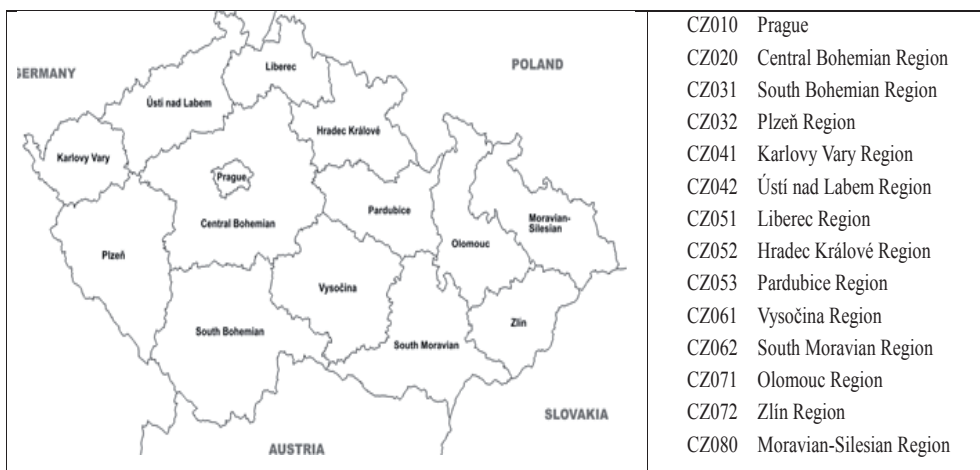
⁴ Data for additional indicators, such as scientific publications or innovation infrastructure, are available only for selected years or for relatively short time periods.

upon request. Data relating to the quaternary sector had to be calculated on the basis of the classification of economic activities and the methodology applied, for example, by Turečková et al. (2023) and Burger & Hovančíková (2021), while also reflecting findings reported by Yan (2025), Miron et al. (2019), Mateides & Ďaďo (2002), and Kenessey (1987). The relevance of the quaternary sector⁵ as an appropriate indicator of learning regions and the knowledge economy has been demonstrated in numerous scientific studies (e.g., Leydesdorff, 2010; Barker, 2006; Pakšiová & Turečková, 2024; Selstad, 1990; Florida, 1998; Nijkamp, 2004).

The Czech Republic consists of 14 NUTS3 regions. Their list, including the codes used in the cluster analysis and the presentation of results, as well as their geographical location within the Czech Republic, is provided in Figure 1. Within regional analyses, Prague may generally be regarded as an outlier due to the dominant effect associated with its status as the national capital. The second-largest city is Brno, located in the South Moravian Region, while the third-largest city is Ostrava, situated in the Moravian-Silesian Region.

Figure 1

NUTS3 regions of Czech Republic



Source: compiled by the authors.

Cluster analysis represents a set of statistical and machine-learning methods designed to identify homogeneous groups of objects based on their mutual similarity or distance. Its objective is to partition observations into clusters in such a way that objects within the same cluster are as similar as possible, while differences between clusters are maximized (Everitt et al., 2011). Cluster analysis belongs to the family of unsupervised learning methods because it does not require predefined classes. Among

⁵ Quaternary sector include all services related to the generation, application and sharing of knowledge, technology, innovation and information, education, science and research (Turečková & Martinát, 2015).

the most frequently used approaches is hierarchical clustering, which creates a tree-like structure (dendrogram) using either an agglomerative or divisive procedure (Landau & Chis Ster, 2010). Part of Ward's hierarchical clustering method is the standardization of variables in order to reduce the variance between clusters. Basic clustering techniques available in IBM SPSS Statistics include the nearest-neighbor method, the furthest-neighbor method, median clustering, and centroid clustering (Meloun & Miličký, 1994).

Given the nature of the data, Ward's clustering method was applied in the empirical part of the study. This technique tends to distribute observations relatively evenly across clusters. Its underlying principle is not the optimization of distances between clusters, but rather the minimization of within-cluster heterogeneity, thereby reducing variability among the observed regions. Multivariate scaling was used because we were not comparing the relationship between two variables, but we needed to compare several variables at once, another reason is the assessment of the relationship between variables in more than one region, in this respect multivariate scaling is a methodologically correct solution. From a practical perspective, the meaningfulness of the identified clusters is of primary importance, particularly with regard to the specific composition of the regions included in each cluster. Similar to factor analysis, cluster analysis is a universal analytical tool that helps researchers better understand regional structures through the application of mathematical methods. Properly identified clusters can improve our understanding of relationships among regions and may also be employed for international comparisons. It should be noted, however, that the resulting clusters reflect the structure of the data only with respect to the selected variables.

To provide an appropriate visualization of the trend in the concentration of learning, knowledge, and creativity, a custom figure was developed (Figure 2; see below). All statistical outputs are presented in the appendices (Appendix A–C). These outputs are discussed and interpreted in the following section devoted to the presentation and description of the research findings (Research Results).

A secondary objective of the article is to assign meaningful labels to the identified regional clusters within the framework of the learning region concept, that is, to distinguish individual regions according to their level of engagement in the set of characteristics developed for this study, encompassing knowledge, learning, creativity, and the closely related domains of science and research. These dimensions are inherently interconnected and cannot be clearly separated from one another. For the classification of regions according to their degree of “learning orientation,” inspiration was drawn from the work of Asheim & Gertler (2005). Based on their approach, four categories of regions are distinguished: (1) knowledge-generating regions⁶; (2) knowledge-adapting regions⁷; (3) knowledge-using regions⁸; and (4) low-/zero-knowledge regions, where engagement in innovation generation and the advancement of learning through knowledge, scientific activity, and creativity remains largely passive⁹.

⁶ Characterized by strong and active research activities, substantial support for R&D, a high concentration of knowledge institutions, and a highly developed knowledge and innovation infrastructure.

⁷ Characterized by limited research activities, lower support for R&D, a lower concentration of knowledge institutions, and an emphasis on the dissemination and integration of existing knowledge, learning processes, and creative outputs.

⁸ Primarily users and recipients of knowledge, characterized by weaker research activity but relatively effective application of existing knowledge, a low concentration of knowledge institutions, and underdeveloped knowledge and innovation infrastructure.

⁹ The available input data do not confirm the existence of this category within the Czech Republic. All regions exhibit a certain degree of endogenous engagement in the examined attributes.

Research Results

Before identifying trends in the concentration of learning, knowledge, and creativity across the NUTS3 regions of the Czech Republic, it is necessary to discuss the results of the correlation matrix of indicators presented in Appendix A. The correlation analysis (Pearson correlation) revealed very strong positive relationships among the selected indicators, including measures of the quaternary sector, educational attainment, and the research and development potential of the regions. All correlation coefficients reached high values ($r = 0.789\text{--}0.982$), indicating very strong positive interdependencies among the selected indicators. This finding can be explained by the naturally strong association among variables that, by their very nature, capture closely related and interconnected aspects of the studied phenomenon. The correlation results obtained are not a problem in the sense of the presented solution, because this is not a classic econometric model, where we always test for multicollinearity between explanatory variables. The high level of correlation in this case is only a confirmation of the tightness of the relationship between the monitored variables. The strongest relationship was identified between the share of the quaternary sector in the economic structure and the share of employment in the quaternary sector ($r = 0.982$), confirming the close connection between the economic significance of this sector and its employment base. Very strong correlations were also observed between expenditure on research and development and the gross value added of the quaternary sector ($r = 0.946$), as well as between the share of persons employed in research and development and the proportion of the population with tertiary education ($r = 0.942$). These findings suggest that regions with a more developed quaternary sector simultaneously exhibit higher levels of human capital, more intensive research and development activities, and greater innovation performance. Finally, it should be noted that all reported correlations are statistically significant according to the t-test results.

The following section presents the concentration of learning, knowledge, and creativity across the NUTS3 regions of the Czech Republic and describes groups of regions exhibiting similar characteristics in the examined dimensions. Based on the conducted cluster analysis, four groups of regions were identified, although their composition changed slightly over the observed period (Appendix C). The clusters were determined for the years 2010, 2017, and 2024. The first cluster (Prague) and the second cluster (the South Moravian Region) remained territorially unchanged throughout the entire period.

The observed shifts occurred between the third and fourth clusters. However, as is evident from both the graphical representation of the clusters (Appendix C) and the descriptive statistics (Appendix B), the differences between these clusters are relatively minor. Consequently, some regions were classified differently in selected years, indicating a reorganization of regions between the two groups. As noted above, the identified clusters exhibit similarities in the observed characteristics, which can also be used to determine the concentration of the examined attributes across regions.

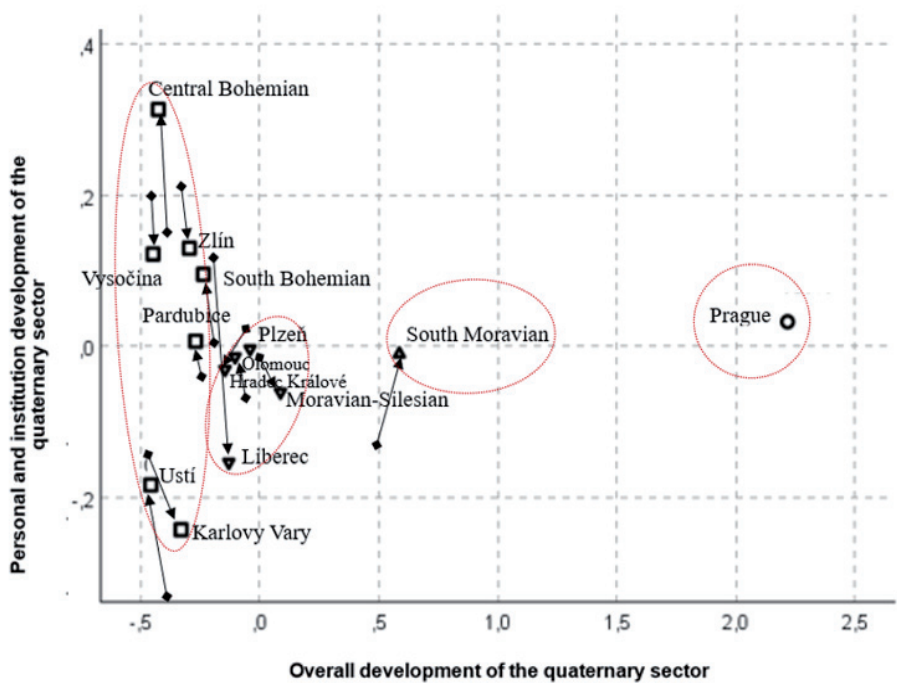
The graphical representation of the dendrogram results¹⁰ (Appendix C) allows for a simplified interpretation: the farther a cluster is located from the y-axis, the higher the concentration of learning, knowledge, creativity, and, more broadly, science and research activities, innovation, and educational attainment within the respective region or group of regions. The regional clusters identified for 2024 are highlighted in Figure 2, where arrows also illustrate shifts in regional positions relative to 2010. This visualization indirectly captures trends in the movement of regions within

¹⁰ No criterion for selecting a four-cluster solution was used; this is based directly on the results of the dendrogram, which determines the number of clusters created.

the framework of the learning region concept. Over the fifteen-year period, the most notable strengthening was observed in the South Moravian, Moravian-Silesian, and Liberec Regions. Other changes were less pronounced or occurred within existing clusters, meaning that although the internal structure of attributes evolved, the overall level of “learning orientation” remained relatively stable.

Figure 2

Clusters of regions by learning and trend of change (2010 and 2024)



Note: The arrow indicates the change between regions from 2010 to 2024 (position of Prague and Plzeň do not change).

Source: compiled by the authors based on information in Appendix C.

The classification of regions according to the proposed evaluation framework for learning-region attributes is presented in Table 1. As noted earlier, the final category (low-/zero-knowledge regions) was not utilized. Instead, the category of knowledge-generating regions was further refined by distinguishing between a leader (Prague) and a follower (the South Moravian Region). This classification reflects not only the results of the cluster analysis but also the descriptive statistics presented in Appendix B (mean values of indicators for individual clusters), which allow for straightforward comparison.

Table 1

Categorization of regions according to the results of cluster analysis

Group	2010	2017	2024
Knowledge-generating regions	Prague (leader) South Moravian Region (follower)	Prague (leader) South Moravian Region (follower)	Prague (leader) → South Moravian Region (follower) →
Knowledge-adapting regions	Central Bohemian Region Liberec Region Vysočina Region Zlín Region	Liberec Region Moravian-Silesian Region Hradec Králové Region Pardubice Region Olomouc Region Plzeň Region South Bohemian Region	Liberec Region → Moravian-Silesian Region↑ Hradec Králové Region↑ Olomouc Region↑ Plzeň Region↑
Knowledge-using regions	Moravian-Silesian Region Hradec Králové Region Plzeň Region Olomouc Region South Bohemian Region Pardubice Region Karlovy Vary Region Ústí nad Labem Region	Central Bohemian Region Vysočina Region Zlín Region Karlovy Vary Region Ústí nad Labem Region	Central Bohemian Region↓ Vysočina Region↓ Zlín Region ↓ South Bohemian Region → Pardubice Region → Karlovy Vary Region → Ústí nad Labem Region →

Note: Arrow indicates change between groups between 2010 a 2024.

Source: compiled by the authors.

A comparison of regional movements between clusters in 2010 and 2024 reveals a clear trend toward a stronger concentration of learning, knowledge, creativity, and related research, development, and innovation activities in the Moravian-Silesian Region as well as in the Olomouc, Plzeň, and Hradec Králové Regions. The position of the Liberec Region as a knowledge-adapting region remained unchanged, as did the positions of Prague and the South Moravian Region within the category of knowledge-generating regions.

In contrast, the pace of adaptation to challenges associated with the knowledge economy slowed in the Central Bohemian, Vysočina, and Zlín Regions, which became part of the knowledge-using regions category. This group also included the South Bohemian, Pardubice, Karlovy Vary, and Ústí nad Labem Regions. The regional classification for 2017 confirms the overall conclusions regarding regional grouping and developmental trends, although the Pardubice and South Bohemian Regions temporarily aligned with the third cluster and would therefore have been classified as knowledge-adapting regions in that year.

Discussion

The discussion of our findings is related to comparable studies conducted on attributes associated with the concept of learning regions in the Czech Republic. Comparisons with similar studies carried out abroad would be of limited relevance and

are therefore not considered appropriate. A literature review identified seven studies that examine either individual characteristics or combinations of characteristics associated with the concepts of learning regions, the knowledge economy, and the quaternary sector, while directly assessing Czech NUTS3 regions (with one exception, discussed below). It should also be noted that many of these publications originate from the previous decade, suggesting a lack of more recent research focused specifically on NUTS3 regions in the Czech Republic.

The first study (Turečková, 2014) examined the concentration of the ICT¹¹ sector among NUTS3 regions during the period 2005–2012. The highest level of engagement in ICT activities was found in Prague, where approximately 60% of all ICT activities were concentrated, followed by the South Moravian, Moravian-Silesian, and Hradec Králové Regions. Žítek & Klímová (2016) investigated the concentration of research activities, emphasizing the importance of research and development expenditure and human resources as key determinants of innovation and scientific progress. Their study, conducted for 2016 and likewise based on cluster analysis, confirmed the dominant positions of Prague and the South Moravian Region. These were followed by the Hradec Králové, Moravian-Silesian, South Bohemian, Olomouc, and Ústí nad Labem Regions. In contrast, regions with relatively weak research performance included the Karlovy Vary, Vysočina, Central Bohemian, Plzeň, Liberec, Pardubice, and Zlín Regions.

Vaculík et al. (2017) analyzed the spatial distribution of innovation activities in the Czech Republic at the LAU 1 level for the period 2010–2012. Although the authors focused on a lower territorial level, their analysis once again confirmed that innovation activities are concentrated in large urban centers, specifically Prague, Brno (South Moravian Region), Ostrava (Moravian-Silesian Region), and Plzeň (Plzeň Region). Minařík & Borůvková (2011) employed a quantitative analytical approach to evaluate the development of human capital across Czech regions in 2008. Their results again confirmed the dominant position of Prague and the Central Bohemian Region, whereas the Karlovy Vary and Ústí nad Labem Regions ranked at the opposite end of the scale. Kováčsová (2014) examined the research potential of Czech regions, that is, the extent to which regions provide favorable conditions for the development of science, research, innovation, and the knowledge economy. Based on data covering the period 2001–2012, her study confirmed that Prague achieved the best results, followed by the South Moravian and Central Bohemian Regions, while the Vysočina, Ústí nad Labem, and Karlovy Vary Regions performed the weakest.

Winklerová (2016) identified indicators of regional innovation potential related to research, development, and innovation and analyzed them at the regional level in the Czech Republic. For the period 2012–2014, Prague emerged as the leading region, followed by the South Moravian, Olomouc, Plzeň, and Moravian-Silesian Regions. The least favorable results were observed in the Karlovy Vary, Vysočina, Ústí nad Labem, and Central Bohemian Regions.

Finally, Bernard et al. (2014) examined whether the most innovative Czech regions were capable of integrating into the global market for highly skilled labor. Their analysis employed the concept of “islands of innovation,” referring to regions where research, development, and knowledge-intensive activities are concentrated. The results were again unsurprising: Prague dominated, Brno represented the second

¹¹ Information and communication technology is a significant industry belonging to the quaternary sector, it is associated with creativity and innovation.

major innovation center, and all other regions lagged considerably behind and were not regarded as key innovation regions.

The findings of these seven studies confirm both our results and our initial assumptions. From the outset, it was expected that Prague and the South Moravian Region would emerge as the principal centers of the knowledge economy, the quaternary sector, and related activities within the Czech Republic. The studies also confirm the persistent underperformance of the Vysočina, Ústí nad Labem, and Karlovy Vary Regions.

Of particular importance for our study is the identification of a group of regions comprising the Liberec, Moravian-Silesian, Hradec Králové, Olomouc, and Plzeň Regions. These regions have developed a substantial knowledge-based, learning-oriented, and innovation-driven potential that may represent an important factor of future endogenous development. In contrast, the regions classified in our framework as knowledge-using regions constitute an area where targeted public support for learning processes appears particularly relevant. Without such public intervention, it is likely that these regions will not be able to independently alter their current development trajectory.

Conclusions

The aim of this article and the associated research was to identify the concentration of knowledge, learning, and creativity in the NUTS3 regions of the Czech Republic during the period 2010–2024 and to examine their transformation over the observed period. This objective was achieved through the application of Ward's hierarchical clustering method to a set of secondary data indicators characterizing the concept of the learning region for the selected years 2010, 2017, and 2024. The analysis not only identified four regional clusters but, in combination with descriptive statistics, also enabled the categorization of regions into three groups according to the concentration of the examined attributes. Furthermore, a developmental trend was identified, illustrating how the concentration of the analyzed characteristics evolved across regions over time.

The main contributions of the research and its findings are as follows: (1) the identification of a set of relevant indicators available at the regional level that adequately capture the characteristics of learning regions; (2) the delineation of four clusters of regions exhibiting similar patterns in terms of learning-related attributes; (3) the classification of regions based on the proposed categorization framework; and (4) the identification and description of developmental trends in knowledge, learning, and creativity over the fifteen-year period under review. An additional contribution lies in the transferability of the proposed methodology and regional classification framework to comparable studies in other countries. The results presented here provide a basis for both scientific comparison and future empirical validation. Based on the literature review and subsequent discussion, it can be concluded that this research not only fills an existing research gap but also offers an up-to-date perspective that reconnects with earlier studies, confirming many of their conclusions while extending them with new evidence.

The research and the conclusions derived from it are subject to several limitations. The most significant limitation is the restricted availability of indicators capable

of adequately capturing learning, knowledge, and creativity within the framework of the learning region concept, as well as the limited temporal coverage of such data. No additional suitable indicators were identified for the regional level analyzed in this study. The discussion of our findings was also constrained by the limited availability of recent studies corresponding both to the territorial level examined and to the substantive focus of the research. A final limitation is the inherent methodological constraint that the classification and evaluation of regions are fully dependent on the analytical framework and methodological approach adopted in this study.

Directions for future research have already been outlined in the introductory sections. The present study has identified clusters of regions exhibiting similar characteristics and has provided an evaluation of these regions in terms of their utilization of knowledge-related assets. These findings will subsequently be compared with the results of a point-based regional evaluation method and an analysis of regional disparities. A second avenue for future research will be to investigate whether the concentration of learning-related attributes influences the developmental dynamics of regions and, if so, to determine the magnitude of this effect.

Finally, it is important to emphasize that the results of the study identified regions that actively utilize and further develop their knowledge base, learning capacity, creativity, research and development activities, and quaternary-sector potential independently (knowledge-generating regions and knowledge-adapting regions). At the same time, the analysis identified a group of regions classified as knowledge-using regions, where there is considerable scope for active public-sector intervention aimed at supporting the development of the examined attributes. These regions appear to lack sufficient endogenous capacity to achieve a deeper level of engagement without external support¹². Given that the analyzed attributes clearly represent important sources of endogenous economic growth, their further activation and development may contribute significantly to regional development and improve the well-being of the populations residing within these territories.

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¹² The public sector can contribute to a more effective use of knowledge in the region by supporting cooperation between businesses, universities, research institutions and other actors. In particular, financing research and development, developing innovation infrastructure and creating conditions for the transfer of knowledge into business practice play an important role. At the same time, human capital development can be supported through education and training, which increase the ability of regional actors to create, share and use knowledge. These tools can contribute to the dissemination of knowledge in the region, strengthening its innovation potential and long-term competitiveness.

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Appendix A:

Correlations

Table A1

Pearson Correlation

Share of the quaternary sector in the overall sectoral structure of the economy (in %)	1	.912	.982	.951	.811	.858	.849	.910	.843	.856
GVA of the quaternary sector (in million CZK)	.912	1	.920	.902	.847	.906	.946	.908	.852	.825
Employees in the quaternary sector as a share of total employment (in %)	.982	.920	1	.931	.838	.874	.873	.911	.869	.865
Share of gross fixed capital formation of the quaternary sector in total gross fixed capital formation (in %)	.951	.902	.931	1	.789	.851	.850	.911	.814	.825
Share of economic entities in the quaternary sector in all economic entities (in %)	.811	.847	.838	.789	1	.849	.854	.837	.859	.849
Share of the population aged 25–64 with tertiary education in the total population aged 25–64 (in %)	.858	.906	.874	.851	.849	1	.924	.942	.889	.833
Expenditure on research and development (in million CZK)	.849	.946	.873	.850	.854	.924	1	.942	.919	.826
Share of persons employed in research and development in the regional population (in %)	.910	.908	.911	.911	.837	.942	.942	1	.930	.869
Research and development workplaces	.843	.852	.869	.814	.859	.889	.919	.930	1	.872
Patents granted to applicants from the Czech Republic	.856	.825	.865	.825	.849	.833	.826	.869	.872	1

Appendix B:

Descriptive statistics

Table B1

Descriptive statistics, 2010

	Ward Method	Share of the quaternary sector in the overall sectoral structure of the economy (in %)	Employees in the quaternary sector as a share of total employment (in %)	Share of gross fixed capital formation of the quaternary sector in total gross fixed capital formation (in %)	Share of economic entities in the quaternary sector in all economic entities (in %)	Share of the population aged 25–64 with tertiary education in the total population aged 25–64 (in %)	Share of persons employed in research and development in the regional population (in %)
Mean	1	42.65	38.07	33.29	29.48	34.63	1.60
	2	15.18	17.26	15.70	18.13	13.51	.29
	3	18.29	20.03	14.86	17.78	12.78	.27
	4	25.03	24.82	16.59	22.49	19.83	.76
	Total	19.62	20.87	16.54	19.06	15.05	.40
Std. Deviation	1	.	.	.	.	.	.
	2	1.63	1.10	2.00	.48	1.48	.12
	3	.62	1.01	2.06	1.58	2.54	.13
	4	.	.	.	.	.	.
	Total	7.14	5.41	5.17	3.45	6.26	.38
Skewness	1	.	.	.	.	.	.
	2	1.73	-1.58	-.97	1.74	.46	-.49
	3	.12	-.45	-1.94	.64	-1.12	-1.05
	4	.	.	.	.	.	.
	Total	2.93	2.78	2.84	2.40	2.59	2.59

Table B2

Descriptive statistics, 2017

	Ward Method	Share of the quaternary sector in the overall sectoral structure of the economy (in %)	Employees in the quaternary sector as a share of total employment (in %)	Share of gross fixed capital formation of the quaternary sector in total gross fixed capital formation (in %)	Share of economic entities in the quaternary sector in all economic entities (in %)	Share of the population aged 25–64 with tertiary education in the total population aged 25–64 (in %)	Share of persons employed in research and development in the regional population (in %)
Mean	1	44.010	40.585	39.906	29.947	45.291	1.927
	2	15.475	18.215	11.706	19.168	17.731	.284
	3	17.937	20.338	13.961	19.129	20.165	.453
	4	25.896	26.734	23.381	22.086	28.282	1.107
	Total	19.489	21.483	15.682	20.127	21.670	.545
Std. Deviation	1	.	.	.	.	.	.
	2	1.811	1.776	1.923	1.293	3.461	.203
	3	.663	1.483	1.693	1.296	.984	.053
	4	.	.	.	.	.	.
	Total	7.623	6.082	7.735	3.145	7.589	.465
Skewness	1	.	.	.	.	.	.
	2	.582	.158	-.129	.933	-.158	.485
	3	.229	1.352	.470	.352	.318	-.442
	4	.	.	.	.	.	.
	Total	2.937	2.706	2.727	2.602	2.572	2.328

Table B3

Descriptive statistics, 2024

	Ward Method	Share of the quaternary sector in the overall sectoral structure of the economy (in %)	Employees in the quaternary sector as a share of total employment (in %)	Share of gross fixed capital formation of the quaternary sector in total gross fixed capital formation (in %)	Share of economic entities in the quaternary sector in all economic entities (in %)	Share of the population aged 25–64 with tertiary education in the total population aged 25–64 (in %)	Share of persons employed in research and development in the regional population (in %)
Mean	1	46.11	42.18	40.43	31.88	52.55	2.34
	2	17.72	20.18	13.79	20.78	21.52	.37
	3	20.45	22.84	18.56	21.21	23.09	.51
	4	28.93	28.50	22.67	24.53	32.13	1.41
	Total	21.53	23.29	18.03	21.99	25.06	.63
Std. Deviation	1	.	.	.	.	.	.
	2	2.66	1.37	1.34	1.97	2.72	.21
	3	1.23	1.13	1.65	1.29	1.27	.11
	4	.	.	.	.	.	.
	Total	7.92	6.01	7.19	3.37	8.61	.58
Skewness	1	.	.	.	.	.	.
	2	.25	-.46	-.31	1.34	-1.15	-.32
	3	1.42	.02	-.47	1.46	-1.27	.09
	4	.	.	.	.	.	.
	Total	2.60	2.71	2.58	2.16	2.84	2.30

Appendix C: Dendrogram

Figure C1
Dendrogram, 2010

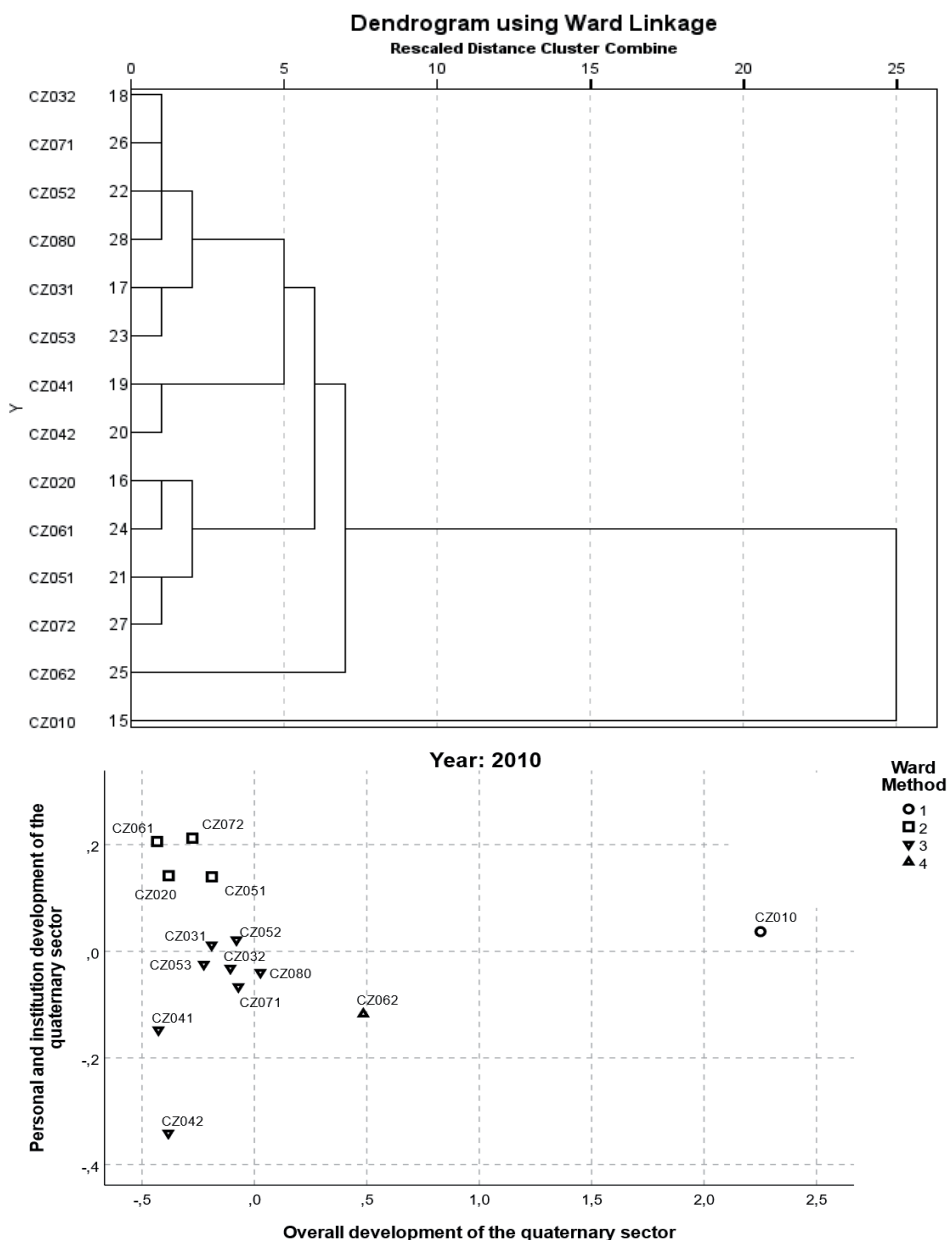


Figure C2

Dendrogram, 2017

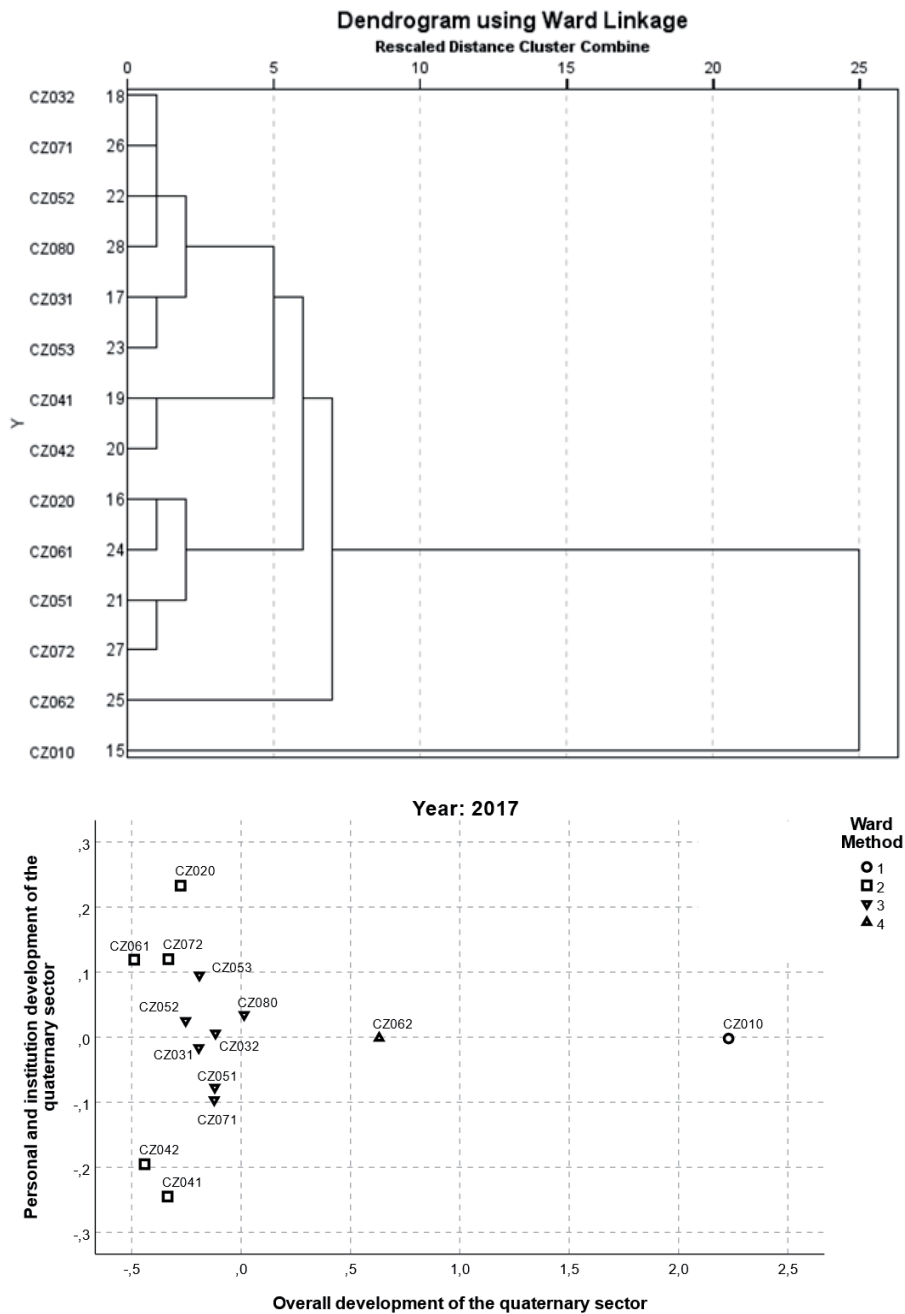


Figure C3

Dendrogram, 2024

