The re-emergence of left-behind regions: The end of spatial equity and the rise of dynamic movements in Slovakia, 1990–2020

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This study explores the spatial and economic shifts in Slovakia over the past three decades in the spatial organization of industrial economic activities. The economic industrial complexity approach is employed to examine the impact of market forces and historical legacies on the crash of the centrally controlled spatial equity organization of jobs and industries and the shift to a more uneven economic landscape. A long time series of data spanning more than 30 years in Slovakia revealed how the artificial territorial organization of job creation policies in each district, enabled by central state planning, has gradually disintegrated. The results display significant spatial divergence and inequality between the capital city and the rest of the country, as well as between urban and rural areas. Two contrasting cases of Bratislava and Košice, the two largest cities in the country, show different spatial relationships with their surrounding regions, explainable using backwash and spread effects. Since spatial and sectoral dynamics are interconnected, spatial shifts and industrial change occurred together. The emergence of creative and knowledge-based economic activities took place against the backdrop of old industrial policies. Košice, the second largest city in Slovakia, faces growing intraregional disparities, so it is worth examining at a micro level how its sectoral trajectory has shifted away from heavy industry thanks to investment in information and communication technology (ICT) and the successful European Capital of Culture project. The microscale of the city reveals patterns of the gradual occupation of territory by the creative sector, particularly by culture and arts, ICT firms and research and development (R&D) entities, exhibiting different locational behaviors.

Keywords:
spatial equity, economic complexity, creative sector, new industrial path

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Introduction – Theoretical framework and motivation

Aggregate quantitative indicators such as gross domestic product (GDP) per capita are used to measure progress in economic development, but they do not reflect the interactions of different segments of the economy or locational relationships. The economic landscape (Martin–Sunley 2010), characterized by the distribution and organization of economic activities, resources, and opportunities across various geographical regions, emerges organically through the self-organization of these activities. This landscape consists of peaks, representing areas with high concentrations of economic resources and opportunities, and valleys, signifying areas with lower concentrations, which together shape the spatial patterns of the economy. The flat world perspective (Friedman 2005) suggests that people and businesses can compete and collaborate more easily than ever before, regardless of their location, because thanks to globalization and technological advancements, economic activities are more evenly distributed and equalizing opportunities across the globe. The accessibility of affordable computers, uniform file formats and transfer protocols, international fiber-optic cable capacity, outsourcing, and several other trends might have significantly equalized the global competitive landscape. Florida argues that, contrary to the "flat world" hypothesis, the world is actually "spiky". He highlights that certain cities and regions, often driven by clusters of creative and knowledge-intensive industries, are thriving and becoming more prosperous, while others are being left behind (Florida 2005, Rodríguez-Pose 2018). If Florida is right, technological advances contribute to a more concentrated economic landscape, and thriving cities attract creative individuals by offering amenities and a diverse cultural climate, which in turn becomes the driving force behind economic growth. Consequently, these development dynamics result in an uneven and spiky world (Rodríguez-Pose–Fitjar 2013). In the domain of innovation, productivity, and creativity, the advantages can outweigh the lower costs related to labor and real estate in less developed areas (Moretti 2012).

Hence, the implementation of market-based systems in postcommunist countries is likely to result in a more uneven spatial distribution of economic activities, resources, and opportunities, creating a "spiky" economic landscape. The primary goal of this paper is to employ enhanced analytical methods to identify the extent of spatial divergence that occurred following the collapse of centrally planned economies using Slovakia as an example.

The aim of territorial justice is to achieve more balanced and inclusive development, reduce inequalities and ensure that all residents have the same opportunities to find work, regardless of their location. Spatial equity refers to the fair distribution of social, economic, and environmental resources and opportunities. However, policies aimed at improving spatial equity often involve redistributing resources from more competitive areas to less competitive ones, which can potentially hinder overall competitiveness. Spatial equity policies have been generally ineffective

in combating market forces leading to spatial concentration (Iammarino et al. 2019). Former communist countries have had unique opportunities to enforce uniform territorial organization due to the dominant or even exclusive ownership of enterprises by the state. In the second half of the 20th century, central planning resulted in an artificial spatial equilibrium of relationships between entities in countries such as Slovakia (Lux–Horváth 2018). After the revolution in 1989, the introduction of the market mechanism abolished the state spatial organization of the economy and set enterprise free. The old and newly emerging actors could suddenly make their own locational decisions and began to create a fundamentally new economic landscape. Therefore, the latter period has served as a laboratory for the study of the rapid progression of new economic self-organization from its zero point. The 'zero point' signifies the moment of complete systemic reset when market mechanisms were introduced, replacing state-controlled spatial organization. From this point, enterprises gained the freedom to make independent locational decisions, leading to the emergence of diverse and novel patterns of economic concentration.

However, this transformation has not only been spatial but also sectoral. The former bloc of communist countries built their economies on massive industrialization, largely in heavy industry, which were not globally competitive after the removal of the Iron Curtain. Postindustrial structural change could lead to the expansion of the service sector and, over time, the creative and knowledge-based sectors. Therefore, the development of Slovakia as a typical postcommunist country can be studied over the past 30 years from these two primary perspectives in their interplay – spatial and sectoral – after unlocking the economy controlled by a central authority.

When searching for a method to explain these complex phenomena of the interplay between different economic sectors and their spatial distribution, the economic complexity approach emerges as a convincing choice (Hausmann et al. 2014). The economy is characterized by network dynamics of interactions between economic agents such as households, businesses, governments, communities, and people. Market dynamics are dispersed at the micro level, with individual decisions affecting the other decisions of all parties and indirectly changing the context for other versions of economic futures and for everyone else (Alberti et al. 2003, Farmer–Foley 2009). Moreover, competition and cooperation between actors is ongoing (Bodin et al. 2019), with the division of labor and specialization exceeding the capabilities of any single economic actor. Economic progress does not take place anywhere; it depends on the amount of accumulated productive knowledge developing the capability to produce increasingly more varied and complex products. Hence, evaluating unobservable effective capabilities for economic growth in an economy can be approximated from export specialization, as the production of complex goods implicitly demonstrates evidence of advanced skills and the capability to effectively integrate them. The main strategic advantage of the economic

complexity approach is the simplicity of the input data and high explanatory power regarding changing specialization and spatial relationships. Consequently, the complexity of an economy is closely interconnected with the complexity of the products it exports, which can be measured by the economic complexity index (ECI) (Hidalgo 2021). Competitiveness and complexity are stimulated by factors such as advanced technological capabilities, improved human skills and strong market orientation. The economic complexity approach has been shown to have strong predictive power. The ECI effectively captures not only the very diversity of the products that a country or region produces but also the knowledge embedded in these goods and services. It can forecast economic growth, income inequality, and even economic resilience, making it a powerful tool for policy-makers and economic strategists.

The creative sector, which is one of the emerging areas, is expected to gradually influence the old industrial profile, indicative of a shift toward knowledge-intensive industries (Florida 2002). In essence, European countries are moving away from traditional, resource-dependent industries toward sectors that leverage human creativity, cultural understanding, and intellectual property. To understand the development of the creative sector from multiple perspectives in a postcommunist country, Slovakia provides "laboratory conditions" to look at how the fall of central organization and increasing self-organization has changed the geography of industries over 30 years.

To explain the transformational dynamics of the postcommunist transition in Slovakia, this study is divided into three interrelated parts, each of which offers unique ways of interpreting this "living experiment" in political-economic system change.

1) Spatial redistribution of economic complexity: This perspective encompasses the exploration of changes in the spatial distribution of economic complexity across the country. It investigates the transition from a homogeneous industrial economic structure to a more diversified one, reflecting the increasing heterogeneity of regional economic capabilities.
2) Redefinition of urban–rural relationships and sectoral transformation: As the country's economic profile changes, so does its urban–rural dynamics. This aspect examines the evolving relationships and interdependencies between urban and rural regions, attributed to agglomeration externalities such as labor market pooling, knowledge spill-overs, and specialized suppliers.
3) Emergence of the creative class and new bohemians: The third perspective is at the city level, exploring the location preferences and patterns of the creative class and the so-called new bohemians. This includes professionals in science and engineering, architecture and design, education, arts, music, and entertainment, whose economic function is to create new ideas, new technology, and new creative content.

Methods and data

This study examines the outcomes of transformation through three main lenses: shifts in the spatial distribution of economic complexity in Slovakia (Part 1), the redefinition of urban–rural relations due to agglomeration externalities (Part 2), and the location of the creative sector in the urban landscape (Part 3). Different research methodologies are used in each section to capture the complex interplay of spatial, sectoral and sociocultural change and postcommunist transformation.

Part 1: The ECI methodology was developed by Hidalgo and Hausmann. The primary data input for ECI calculations is country-product level export data. A binary country-product matrix is constructed, and each cell is 0 or 1, indicating whether a country is a significant exporter of a certain product. A country is a significant exporter of a product when its proportion of world exports or that particular product exceeds its overall share in total world exports. The ECI itself is then computed through an iterative process known as the "method of reflections", which essentially involves repeatedly reweighting the diversification and ubiquity measures based on each other.

Export data are collected and reported at the national level. Therefore, instead of being classified by the produced and exported goods and services, each economically active enterprise is allocated to one of the 19 sectors under the statistical classification of economic activities (nomenclature statistique des activités économiques dans la Communauté européenne – NACE) classification system. The ECI score for Slovakia's 79 districts is based on the number of active enterprises in each district, categorized according to the European Community's statistical classification of economic activities (NACE 2). Furthermore, geographic information systems (GIS) software helps visualize spatial changes in economic complexity. "Dataset of firms and organisations" [3] is employed, which contains precise establishment and termination dates for enterprises as well as detailed classification into 87 categories. This dataset provides a longer commercial history, extending back to 1990, the birth year of the earliest private enterprises, covering more than three decades of commercial activity and the transformation of business demography in Slovakia. By using Finstat's data [3], we can examine the situation from the earliest stage of the market introduction, tracing back to the days when the centrally planned economy was just beginning to disintegrate. The ECI for districts is determined through an iterative process that measures the diversity of industries in a district and the ubiquity of these industries across districts. First, a bipartite network of districts and industries is formed. Initial measures of district diversity and industry ubiquity are calculated, with diversity signifying the range of industries in a district and ubiquity indicating the presence of an industry across districts. This process is refined iteratively, with each step recalculating the ubiquity of an industry based on the average diversity of districts it is found in and the diversity of a district based on the average ubiquity of its industries. The progression continues until convergence is achieved, leading to the

final ECI ranking for each district, reflecting the economic complexity of their industrial composition. Essentially, an industry becomes less ubiquitous when located in districts that are less diverse, and a district becomes more diverse when it has industries that are less ubiquitous. The concept behind this is that the complexity of a district's economy is revealed not only by the number of different industries it supports but also by the "exclusiveness" of those industries. The analysis was performed in R using the "economiccomplexity" package (Vargas 2022).

Spatial autocorrelation is used to measure the degree of correlation among spatial features and to identify patterns in the distribution of economic activities. It enables the understanding of how much the economic profile of one district is influenced by its neighboring districts. This approach is vital for tracing the geographic evolution of economic sectors. Moran's index I (Moran's I) is a measure of spatial autocorrelation, providing insight into how closely related the values of the same variable are across different spatial units. It ranges from –1.0 to 1.0, with positive values indicating positive spatial autocorrelation (similar values are found together), negative values indicating negative spatial autocorrelation (dissimilar values are found together), and a zero value implying a random spatial pattern. In this article, Moran's I is used to understand the evolution of spatial autocorrelation over the last three decades, specifically within the territorially distributed economic system of Slovakia. This tool helps capture the self-organizing process that has been underway in the nation's economic landscape. Furthermore, Moran's I allows for the identification of specific local clusters of activity or the influence of spatially located factors (Anselin 1995). Implementation of Moran's I in this context involves using spatial weights between neighboring districts based on common borders. Moran's I close to 0 suggests that the economic complexity is randomly distributed. This could suggest spatial equity, as there would be no distinctive pattern of concentration in access to resources.

Part 2: Focusing on a city and its neighborhood, we aim to better understand the spatial and temporal dynamics of economic complexity. We narrow our focus to the microscale, examining the city of Košice and its suburban area. The city of Košice is divided into four districts: Košice I, II, III, and IV, which are analyzed in conjunction with the surrounding suburban fifth district referred to as "Košice-okolie" (Košice surroundings). The analysis covers a total of 112 municipalities within the Košice-okolie district and an additional 22 urban districts within the city of Košice itself. We map and investigate the evolution of economic complexity similarly to the previously conducted regional-scale analysis. The data for this investigation come from the Finstat database [3], utilizing the 'economiccomplexity' package in R for computations. Spatial autocorrelation is then measured through Moran's I. Furthermore, enterprise identification data are sourced from the Register of Financial Statements, maintained by the Ministry of Finance of the Slovak Republic (2022), and geographical boundaries and labels come from GKÚ Bratislava [4].

Part 3: An econometric model in a spatial panel format is aimed at capturing the outlined processes leading to the selection of urban locations and the concentration of creative industries. The spatial autoregressive Durbin model assumes that observations of the dependent variable are chained together in a two-dimensional medium of physical space. The spatially dependent part of the residuals simply includes all the uncovered systematic effects. The approach exploits the history of previous stages of itself, the distribution of population densities and the distribution of selected anthropogenic functional-spatial categories to explain the locational behavior of the creative sector. In terms of the model parameter labels, λ refers to the spatial autocorrelation regression coefficient of the spatially lagged dependent variable y, while ϱ refers to the spatial autoregressive parameter of the spatial part of the model error ε. The shape of the model following Millo–Piras (2012) is as follows:

$$y = \lambda(I_T \otimes W_N)y + X\beta + u$$
$$u = \lambda(\iota_T \otimes I_N)\mu + \varepsilon$$
$$\varepsilon = \rho(I_T \otimes W_N)\varepsilon + \nu$$

The W_N spatial weights matrix is used to depict the spatial relationships between observations at microlocations. The chosen raster format of the spatial data is arranged in rows and columns of square cells. A cell neighborhood is defined as a surrounding zone of eight cells that are assumed to be functionally related to what is happening in the microlocality (Moore neighborhood). The grid is made up of cells one kilometer wide, a realistic assumption of a radius of comfortable walking distance. A series of spatial models is therefore estimated with the inclusion of fixed effects of $\eta_t$time periods.

Spatial redistribution of economic complexity

During the centrally controlled industrialization in the second half of the 20th century, a regionalized spatial structure of districts in Slovakia was established with a dominant state-owned enterprise in each district. Districts were based on the model of Christaller's central place postulates (Getis–Getis 1966), proposing that economic activities and human settlements tend to be organized in hierarchical spatial patterns, with central places serving as hubs for surrounding areas. Even today, each district (okres) is named after a central district town; 10-15 districts together have a regional capital, which again gives its name to the region (kraj). With the opening up of markets and competition after 1989, the country was unable to maintain the artificial spatial organization that had been initially built. The economic complexity approach enables a more in-depth explanation of the recent considerable changes in the national, urban–rural and intraurban structure of cities after the fall of the communist regimes. Certainly, new patterns of disparity and peripheralization processes (Tagai et al. 2018) can be expected to emerge, despite European Union (EU) funds supporting regional competitiveness.

In addition, with the establishment of an independent Slovakia in 1993, a new European capital, Bratislava, was created. This attracted institutions and investments for the whole of Slovakia. A well-known argument for the emergence of interregional disparities is the eccentricity of Bratislava located on the border with Western Europe; disparities show a clear west–east gradient toward the Ukrainian Schengen border. The communist Central Authority had previously had the power to orchestrate the allocation of jobs to the places where people lived to keep them living in their region. At present, people have already been driven by economic circumstances to move to where jobs exist and firms are optimizing their location in space (Van Dijk et al. 2019), leading to new economic and social geography. In the context of regional development, backwash effects or centripetal forces refer to factors that promote the concentration of economic activities and resources toward specific centers or core regions, such as agglomeration economies, better infrastructure, access to markets and skilled labor (Colby 1933, Schad et al. 2019). On the other hand, spread effects or centrifugal forces refer to factors that drive the spread of economic activities and resources away from core regions, such as inadequate infrastructure, land prices or cost of living. In a situation where the spatial equilibrium protected by centralist interventions was disturbed, a dominant backwash (centripetal force) effect emerged, concentrating economic power and economic complexity in cities and regions with favorable locations and superior endowment factors. Similarly, a wide range of diverse economic activities would gradually concentrate in a few emerging cities due to agglomeration externalities. Once existing capacities in some cities become saturated and negative externalities arise (overcrowding, rising costs of living), spread (centrifugal forces) effects could become more prevalent, pushing further investment and employment to surrounding areas. Dynamic spatial processes would gradually lead to a new equilibrium or at least shift economic spatial patterns to a new stage of development (Schad et al. 2019).

The hypothesis on the substantial rearrangement of economic activities is explained using spatial autocorrelation and complexity measures. The economic complexity methodology is still being developed, and the indicators are calculated by competing algorithmic procedures. We utilize the ECI (Hidalgo 2021), typically used on export data at a country-product level, and adapt it to the context of districts and industries based on the number of active firms in each. The ECI is derived through a set of iterative linear equations that capture the interplay between the ubiquity of industries and the diversity of firms across districts. The environment in the R package economic complexity 1.1 was used for the calculations.

The evolution of economic specialization was examined using the ECI score of the 79 districts in Slovakia over 30 years. The top 20 in the group out of 79 in 2020 (Table 1) are represented by the districts of Bratislava and Košice, the two largest cities, and the regional centers (Banská Bystrica, Žilina, Nitra, Trenčín, Poprad), while the rest (Senec, Pezinok, Malacky, Komárno, Dunajská Streda) are growing neighboring districts to Bratislava.

Table 1

Economic complexity index score, best performing districts in 2020

District	1990	2000	2010	2020
Bratislava V	1.73	2.90	3.16	3.30
Bratislava I	2.82	2.77	2.74	2.95
Bratislava III	2.10	2.92	2.69	2.77
Bratislava IV	2.55	2.29	2.78	2.64
Bratislava II	2.28	2.66	2.59	2.47
Senec	0.94	1.38	1.77	1.64
Banská Bystrica	1.65	1.86	1.33	1.48
Pezinok	0.83	1.01	1.88	1.36
Košice III	–0.45	1.10	1.79	1.32
Košice I	2.03	2.09	1.67	1.30
Košice IV	1.15	0.73	0.39	1.26
Malacky	–0.25	0.69	1.04	1.06
Komárno	0.18	0.13	1.09	1.00
Žilina	1.68	1.01	0.63	0.89
Poprad	0.37	1.02	0.31	0.73
Dunajská Streda	0.35	0.23	0.48	0.66
Košice II	0.52	–0.18	0.17	0.61
Nitra	0.88	0.31	0.39	0.60
Trenčín	1.13	0.70	0.47	0.50
…	…	…	…	…

The ECI shows the changes in the landscape following the resignation of the central management of spatial organization in terms of keeping jobs in each district. This has led to the dominance of the larger cities and, in the case of Bratislava, the districts adjacent to it. It also highlights the decline of smaller and peripheral districts. The spatial distribution of values up to 10 quantiles is shown in the Appendix Figure A1, with the highest ECI values in red and shades changing toward blue corresponding to the lowest ECI values. Overall, the position of the capital Bratislava region has strengthened over this time.

Moran's index I (Anselin 1995) evaluates spatial autocorrelation and whether the expressed pattern of economic complexity is clustered, dispersed, or random. The values of Moran's I range from -1.0 to 1.0. The random ordering is manifested by a value of Moran's I close to zero, which corresponds to the centrally established spatial distribution of state-owned industrial firms in each district of Slovakia. The emergence of spatial concentrations with similar values increases the Moran's I values toward 1 where the reallocation coincides with the transition period as the market environment is introduced.

The original pattern established by central economic planning in 1990 (Appendix Figure A1) is close to spatial randomness due to the established structure of regional and district centers. The disturbance of the equilibrium has gradually changed into more clustered patterns and can be documented by the increasing positive values of spatial autocorrelation. Moran's I values (Appendix Figure A2) have shown how patterns have changed from an organized spatial structure to a clustering of high-high and low-low wider areas. The regional complexity nodes in 1990 still corresponded to the eight regional metropolitan areas. The west–east gradient of economic development has gradually weakened the complexity in the east of Slovakia and only persisted in Košice, the second largest city. Meanwhile, the backwash agglomeration forces attracted resources and talent from less developed regions, widening the intraregional gap in the east of the country. The formation of a larger spatial area of economic complexity in the central part of Slovakia between the three cities relies on a combination of industrial and tourist developments.

Unique emerging specializations are more likely to occur in new ventures in conditions of high density of diverse business activities (Duranton–Puga 2000) due to talent availability, knowledge spill-overs and interindustry relationships. Smaller towns and economic peripheries have experienced a gradual deterioration in specialization profiles toward lower complexity. Higher complexity has not only been preserved but actually increased in the environs of Bratislava as well as in central Slovakia. Bratislava has been a major magnet for investment in all sectors, especially in knowledge-intensive services. As such, it has been able to pull investment and human capital from abroad and other parts of Slovakia. Consequently, the emerging negative externalities in the capital city, especially transport capacities and rising land and housing prices, have progressively dispersed the positive effects into the surrounding districts, forming a continuous red belt of economic complexity. Another advantage of the area in the wider surroundings of Bratislava is the locationally advantageous conditions near the borders with Austria, the Czech Republic and Hungary as well as the lowland geographical profile.

Redefinition of urban–rural relationships and sectoral transformation: From old industries to the new knowledge-based and creative sector

If a finer scale is used, changes are visible both inside the city and in the relationship between the city and the hinterland. Smaller towns and economic peripheries have experienced a decline in their specialization profiles, moving toward lower complexity. In contrast, the complexity and specialization in and around Bratislava, the capital city, have been preserved and even increased. The broader region of Bratislava experiences spread effects, and the phenomenon of suburbanization and the transformation of the hinterland of Bratislava is well documented (Šveda–Šuška 2020). Košice may experience some degree of backwash effects.

The city of Košice lies in eastern Slovakia. The maps in the Appendix Figure A3 show the gradual concentration of complexity in the city measured again by ECI scores and at the expense of the hinterland. This has led to an intensification of intraregional disparities. Košice is the main center in the east, and the previous analysis revealed a shrinkage of economic complexity and weakening of the region in terms of attractiveness for investment. However, the region and the city have gradually been losing human capital due to the brain drain and overall losses in the diversity of economic activities. This is most significant in the Czech Republic and increasingly in the Bratislava region. Moreover, heavy industry employment has been reduced to one-third compared to its peak years. Therefore, the strength of Košice has not yet been sufficient to generate impulses to its surroundings. Despite the city absorbing significant investments and labor from wider surroundings like a sponge, its population has still declined slightly.

Fortunately, the shortfall in heavy industry was compensated by the arrival of ICT firms at the beginning of the 21st century. This has fostered greater employment opportunities for younger generations and an influx of new professionals. Accordingly, backwash effects should preserve the economic complexity in the city but generally worsen in the nonurban city neighborhood. Moran's I statistics were used again to identify spatial autocorrelation using five quantiles. The territory of the city of Košice consists of four districts, Košice I-IV, and the map is supplemented by a wreath of rural areas around the city called the Košice-surrounding district (Košice-okolie). In total, the map covers 112 municipalities of the Košice-okolie district and 22 urban districts (Appendix Figure A4).

The Moran's I value of spatial autocorrelation over three decades (Appendix Figure A5) captures the self-organizing process of the city of Košice and its immediate periphery. A positive spatial autocorrelation was already evident in 1990, and over three decades, it further increased from 0.4 to values close to 0.6. The notable escalation in Moran's I during the period 2005–2015 can be primarily attributed to the arrival of several ICT companies, coupled with the subsequent amplification of the cultural and creative industries in the wake of Košice's designation as the European Capital of Culture in 2013. These elements combined might explain the spatial autocorrelation pattern we observed over the three decades (Rehák et al. 2013, Šebová–Hudec 2012).

While the built-up area of Košice maintains high economic complexity and positive development, it lacks sufficient support from the surrounding area, which is experiencing decline and is dependent on the center. This presents a rather precarious tendency and questions about the sustainability of growth for the city of Košice itself. While the city center is thriving, the surrounding areas are lagging, creating disparities in wealth, opportunities, and quality of life. The surrounding areas are becoming increasingly dependent on the city center, and the lack of support from the surrounding areas could undermine the sustainability of the city's growth.

In addition to urban–rural interactions, 30 years must have also brought changes in the sectoral structure. The presumption of an increasing number of knowledge-based and creative jobs being concentrated in urban environments (Lazzeretti et al. 2012) has been confirmed (Appendix Figure A6). After the abolition of central planning, the concentration of cultural and creative activities in the wider Košice city center (indicated in red) steadily increased. Institutions such as Tabačka Kulturfabrik and Kulturpark represent these growing creative communities and spaces, embodying their values, aspirations, and lifestyles. They are part of the transformation of the city center into a hub of creativity and innovation, a place where the creative class, the generational movement, and the bohemians find a home and a platform to express, create, and innovate. The location of creative firms and their impact on the inner-city fabric is examined in the last section.

Emergence of the creative class and new bohemians: Does the creative sector have a favorite territory?

The investigation of establishments with main activities in the creative industries according to the way they use the urban territory works with the hypothesis of their proximity to each other (Smit 2011). Proximity is essential for knowledge spill-overs and the use of amenities present in some parts of the urban agglomeration, especially the proximity to the center and visual quality of the district. The visual quality of a place is significant for both personal preference and as an element of a creative company's image. The visual appeal of a location where a creative company is based plays a crucial role in attracting customers and visitors, strengthening brand identity, and displaying the firm's creativity and innovation; thus, it becomes an important factor in the choice of the company's location. Indeed, there seem to be two primary factors influencing the choice of location for creative industry establishments as per the hypothesis: proximity and visual quality (Gibson et al. 2010).

Hence, the question arises as to how the nature of the knowledge-based and creative services sector (KBCS sector) is translated into locational preferences. Moreover, heterogeneity may also manifest itself inside the sector. The locational behavior of a trinity of creative industries (culture and arts, ICT firms and R&D entities) represents the activities of the creative class, people who are engaged in the development of new technologies, solutions, design and other forms of innovative work. We are aware of the limitations in using the term "knowledge-based and creative services" as it is not an official NACE classification. The term is broader and more inclusive, encompassing not only knowledge-intensive business services, as discussed in (Kézai–Rechnitzer 2023) but also creative and artistic industries. It acknowledges the significance of both knowledge and creativity. We can identify and group together the relevant NACE codes: the term includes industries that deal with the creation, production and dissemination of knowledge and creativity, such as

technology, media, design, research and related services. For simplification, we use the following abbreviations: "Information and Communication Technology" (ICT), "Research and Development" (R&D), and "Arts and Entertainment" (Arts).

A specific subculture of new bohemians is forming with a specific healthy lifestyle of walking and cycling and gastronomic diversity and sophistication. Thus, it seems that the creative sector has expectations about the quality of place and can form a generational community or localized movements within a circumscribed area. ICT companies and self-employed people may have different placement preferences from artists. The field of digital products and services has a strong mainstream of large, often global corporations. However, it also has a vital stream of experimental business start-ups that tirelessly explore every niche suitable to apply a potentially successful idea. Indeed, digital production is extremely economical on the input side, standing only on the unique recombination of knowledge (Lanzolla et al. 2021). The limitations of ICT are its domain neutrality and its requirement of complementary content to be successful. This is brought into play by professionals whose profession is, for example, research and development, universities or commercial laboratories engaged in the systematic creation of new knowledge.

An econometric model in a spatial panel format, as explained in the Methods and Data section, aims to capture the outlined processes leading to the selection of urban locations and the concentration of creative industries. The spatial autoregressive Durbin model assumes that observations of the dependent variable are chained together in a two-dimensional medium of physical space. People are more likely to establish stronger and more frequent relationships with those who are nearby than with others who are far away. Consequently, studying spatial and temporal factors in the model provides an explanation for the former location decisions.

The database is a list of active companies in the creative industries that have registered over time and operate from a registered office address in Košice ([3], Ministry of Finance of the Slovak Republic 2022). After overlaying the cells of the kilometer grid covering Košice, the database has 12,700 entries, half of which are categorized with the main activity in the sectors ICT (J), R&D (M) and arts (R). The time series is constructed as of December 31, 1990, 2000, 2006, 2012 and 2018. The grid has 304 cells, and a time series of categorized satellite imagery from the Corine Land Cover service [2] is used to determine the proportions of urban land use. This selects several anthropogenic land use types that are related to the location of the creative sector: Continuous City, Discontinuous City, Commercial Areas, Roads, Areas under Development, Urban Green Space and Sports and Leisure (Table 2). The continuous city category (1.1.1) is made up of an area with a continuous urban morphology (urban centers and dense historic suburbs where buildings form a continuous and relatively homogeneous structure).

Table 2

Variables of the statistical model for the locational development of the urban creative sector

Category	Variable	Indicator
Located companies	KBCS	Number of companies in categories J, M, N, R, S, U per km²
	ICT	Number of companies in category J per km²
	R&D	Number of companies in the M category per km²
	Art	Number of companies in the R category per km²
Population	Population	Number of permanent residents in thousands per km²
Functionally spatial structure of the territory	Connected city	Share of Corine land cover category 1.1.1
	Disconnected city	Share of Corine land cover category 1.1.2
	Commercial	Share of Corine land cover category 1.2.1
	Pathways	Share of Corine land cover category 1.2.2
	Construction	Share of Corine land cover category 1.3.3
	Greenery	Share of Corine land cover category 1.4.1
	Sports and Leisure	Share of Corine land cover category 1.4.2

Table 3

Average level of variables entering the model of KBCS sector location in Košice in a grid with a resolution of the location km²

Denomination	1990	2000	2006	2012	2018
KBCS	0.619 (2.939)	6.666 (28.497)	11.861 (47.118)	19.993 (75.231)	28.848 (102.953)
ICT	0.017 (0.128)	0.613 (3.219)	1.017 (4.710)	2.013 (8.010)	3.033 (11.162)
R&D	0.060 (0.331)	1.550 (6.636)	3.129 (12.328)	6.377 (24.645)	8.798 (32.175)
Art	0.205 (0.946)	1.414 (5.040)	2.023 (6.835)	2.646 (8.471)	3.361 (10.455)
Population	0.789 (1.862)	0.802 (1.873)	0.813 (1.912)	0.824 (1.976)	0.836 (2.063)
Connected city	0.351 (3.562)	0.351 (3.562)	0.351 (3.562)	0.351 (3.553)	0.351 (3.553)
Disconnected city	11.192 (23.289)	12.353 (24.199)	12.341 (24.005)	12.960 (24.667)	13.167 (24.800)
Commercial	5.806 (18.310)	6.280 (18.889)	6.085 (18.666)	6.143 (18.638)	6.142 (18.639)
Pathways	0.957 (5.933)	1.196 (6.271)	1.106 (6.17)	1.103 (6.175)	1.093 (6.174)
Construction	0.492 (4.150)	0.104 (1.362)	0.194 (1.722)	0.090 (1.063)	0.090 (1.063)
Greenery	0.206 (1.723)	0.626 (4.139)	0.623 (4.138)	0.454 (3.575)	0.454 (3.575)
Sports and Leisure	0.791 (4.777)	0.493 (4.180)	0.573 (4.279)	0.586 (4.347)	0.586 (4.347)

Note: The standard deviation is in parentheses.

Source: Authors' calculations based on data from the Copernicus Land Monitoring Service (2022), [1], [3] and Ministry of Finance of the Slovak Republic (2022).

Over the 28 years recorded, the increase in the size of the creative sector is significant. On average, there are nearly thirty firms in the KBCS sector for every km^2 of land in Košice in 2018. However, the majority of actors in the creative industries are companies without employees or self-employed persons. At the turn of the century in 2000, this figure was barely seven firms (Table 3).

A static panel with spatial autocorrelation correction in the dependent variable and a simultaneous spatially autocorrelated error term was chosen to grasp the dynamics of the KBCS sector. The left-hand side of the equation is the differenced level of each sector and their sum. Explanatory variables on the right-hand side are kept in the form of the initial level, while the contextual variables describing the functional structure of the city and the population are augmented with the levels of the trinity of industries (ICT, R&D and arts).

Table 4 shows the substantial periods of change in Košice, marked significantly by the arrival of ICT companies in the first decade (Rehák et al. 2013, Šebová–Hudec 2012) and the emergence of the cultural sector associated with the successful European Capital of Culture in 2013 (Hudec et al. 2019). The two incentives are slightly different. The ICT sector has experienced an investment window of time for the arrival of foreign ICT firms that have integrated into the existing local environment. However, the modern cultural and arts scene was weakly present in the city. The millennials appropriated the European Capital of Culture project awarded to them and kick-started the creation of new cultural infrastructure and inventive meeting places and crowded the city with cultural activities by implementing a culture-led development strategy.

It is important to identify a nuanced pattern of locational preferences among different industries. Table 4 presents the impact of various factors on the presence of knowledge-based and creative firms in Košice. The impacts are examined within the grid cell (direct) and from neighboring grid cells (indirect), accounting for the spatial interconnectedness of these variables. The Total column represents the sum of Direct and Indirect effects.

All direct, indirect and total effects are statistically significant and, with the exception of the ICT sector, positive. It turns out that the division into three groups offers explanations for the different location behaviors. The ICT variable has a negative effect, implying that ICT firms seek proximity neither to other ICT firms nor to other KBCS sector firms. In contrast, the R&D firms show a significant positive overall effect, implying that an increase in the number of R&D and arts firms is associated with an increase in the total number of creative firms. This suggests that these sectors contribute to a favorable environment for the development of the creative industries. Additionally, the growth of the KBCS sector is related to the location of the resident population; namely, entrepreneurs register their small-scale activities within an experimental sector in their place of residence. While the presence of R&D and art firms promotes further growth of the KBCS sector, the presence of

ICT firms has had the opposite effect, which is related to bid rent (what someone is willing to pay for land in relation to its distance from a city center). ICT firms have a negative effect on the growth of the whole sector in Košice, as they have the capacity to pay higher rent prices for desirable locations. Additionally, their choice of location may have consequently further increased the price of land and property in these areas. The ICT sector is superior economically and does not seek proximity to competing firms.

Table 4

Effects of explanatory variables on all creative firms combined

Denomination	Direct	Indirect	Total
ICT	–1.691 (0.219)***	–0.458 (0.103)***	–2.148 (0.284)***
R&D	0.794 (0.069)***	0.215 (0.046)***	1.009 (0.095)***
Art	1.417 (0.176)***	0.383 (0.087)***	1.800 (0.232)***
Population	2.701 (0.328)***	0.731 (0.187)***	3.432 (0.470)***
Connected city	193.727 (9.931)***	52.425 (11.359)***	246.152 (18.007)***
Disconnected city	9.100 (2.217)***	2.463 (0.766)***	11.562 (2.836)***
Commercial	–2.569 (2.101)	–0.695 (0.594)	–3.264 (2.678)
Pathways	–7.670 (5.442)	–2.076 (1.644)	–9.746 (7.030)
Construction	–7.783 (11.160)	–2.106 (3.034)	–9.889 (14.126)
Greenery	–25.412 (8.317)***	–6.877 (2.663)***	–32.289 (10.631)***
Sports and Leisure	–22.336 (7.260)***	–6.044 (2.486)**	–28.380 (9.483)***

Note: The impacts spread across the boundaries of neighboring grid cells through spatial autocorrelation effects estimated iteratively as a direct effect (inside the cell) and an indirect effect (around the cell); statistical significance – *10%, **5%, ***1%.

All three sectors considered are linked by a continuous urban environment with block development, which in turn creates a strong growth effect. It is important in this context that knowledge-based and creative firms and freelancers also thrive in the proximity of the historic buildings in the city center. Unlike artists and R&D, ICT firms are outside the repelling effects of transport infrastructure – they are able to find more comfortable spaces in quieter surroundings, although they are still close enough to other creative firms.

Conclusions

Several centrally ruled countries, including Czechoslovakia, implemented state policies to shape spatial equality and control job supply through measures such as spatial job creation based on district population. This model could only exist in closed economic systems without enabling private entrepreneurship and in isolation from competition. After 1989, a transformation emerged that could be expected to gradually shape a new equilibrium in spatial organization, specialization and concentration. The resulting uneven economic development and disparities between regions have contributed to the spiky nature of the current economic landscape. The adoption of market systems in postcommunist countries has also been confirmed to lead to a more unequal spatial distribution of economic activities, resources and opportunities. The economic complexity approach confirms the challenge of divergence that emerged after the collapse of centrally planned economies in the example of Slovakia.

Structural changes over three decades were attempting to catch up with developments in Western Europe, while the persistence of the old industrial policy principles has been a barrier to the development of the knowledge base and creative sector. After a time, the spread effects behind economic dynamism provided incentives for the economic growth of the broader area of Bratislava. The dark side of this development has been the shrinking economic complexity in the more distant districts and the dominant effects in the regional capitals prevailing over their peripheries. We interpret the 30-year evolution of change as a living experiment in spatial organization utilizing an economic industrial complexity approach to gain insights into market-driven spatial divergence from previous spatial equity. There are some different dynamics between the capital city, Bratislava, and the second city, Košice. The capital city of Bratislava has increased its economic complexity, spreading to the surrounding districts, and a region of high economic complexity referred to as the "red belt" has been created. However, the story of Košice in the east of the country is different. Backwash effects prevail, and given the less prospective situation, it makes sense to examine in more detail the city's relationship with its nearby rural surroundings, as well as the impact of sectoral changes on the geography of new industries in the city itself. The city and region have faced challenges in maintaining economic complexity, but the arrival of ICT firms and growing local creative activities have provided some compensation. However, there are obvious adverse effects, as economic complexity generally worsens in nonurban areas. The strength of the city is not sufficient to generate significant impulses to surrounding areas. Although the city has absorbed investment and labor from the wider area, its population has declined slightly.

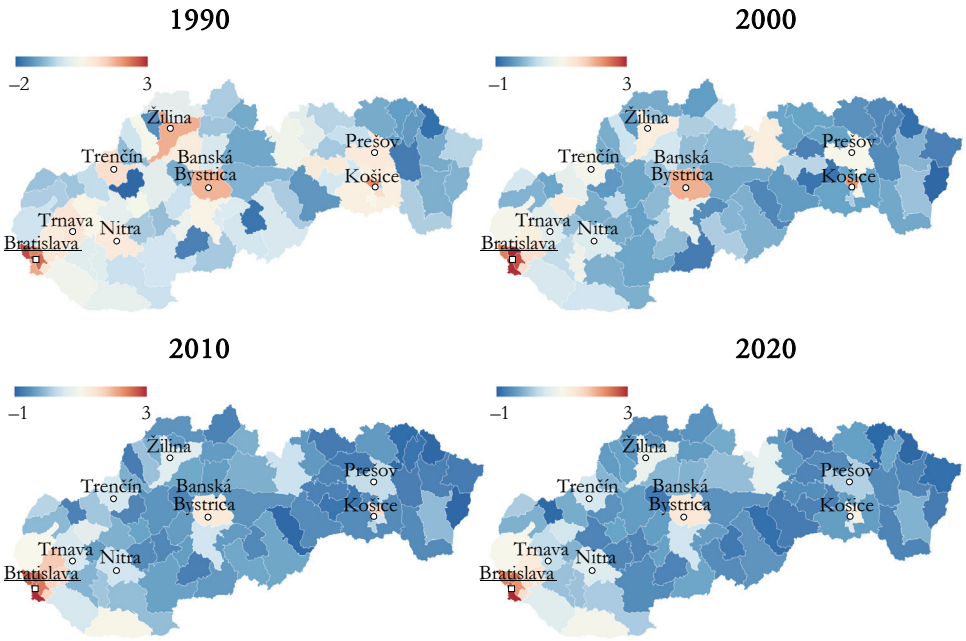
The creative sector and ICT, with the support of science and research, could play a key role in economic growth. The study of the intersection of knowledge-based and creative industries could reveal sources of economic growth and job creation, which

presumes proximity and knowledge spill-overs. Understanding the locational patterns of their behavior could inform urban and regional development strategies, encourage regional innovation ecosystems and promote economic diversification. We observe an overall positive association of the growth in jobs occupied by arts and R&D firms, suggesting that there is a considerable preference for proximity to creatives by ICT firms as well. The rise of the sector is linked to the postindustrial era and the emergence of a relatively new group of people in the city, also referred to as the creative class, looking for places that suit their lifestyle. There have been interesting differences identified in preferences for location decisions. Culture and arts, the new bohemians, are concentrated in the nearby center within walking distance of cultural facilities, gradually adopting a territory of their own. The community is fueled by interpersonal interaction, networking, and the mutual transfer of creative ideas to each other. However, ICT firms are not as keen on having other ICT firms in the vicinity. Hence, the KBCS sector is strongly structured internally, and its locational evidence contains a promising lesson about its importance in shaping the postindustrial future of the city. The arts, R&D and ICT already have a role to play in the inner city and the wider environment.

Appendix

Figure A1

Economic complexity variation across 79 districts of Slovakia



Note: The variation is depicted using a continuous linear scale color gradient from blue (representing lower ECI values) to red (representing higher ECI values). Map data: ZBGIS (2023).

Figure A2

Territorial differences in economic complexity between the 79 districts of Slovakia: time series of Moran's index I (MI)

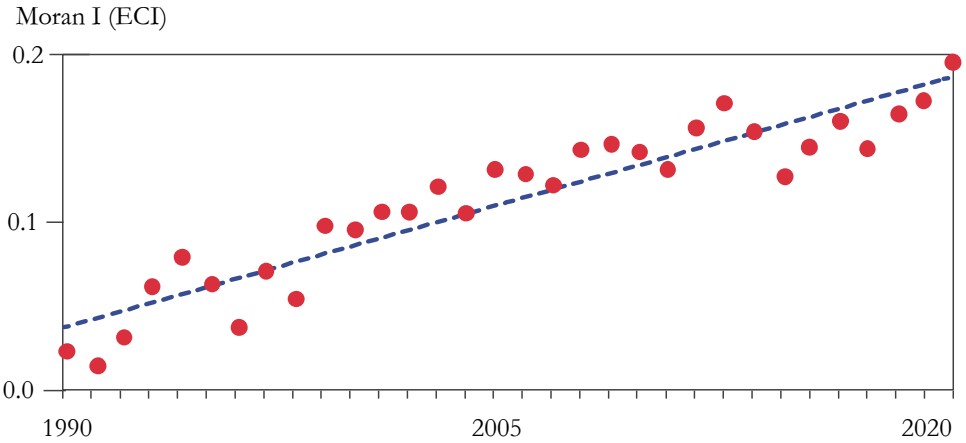
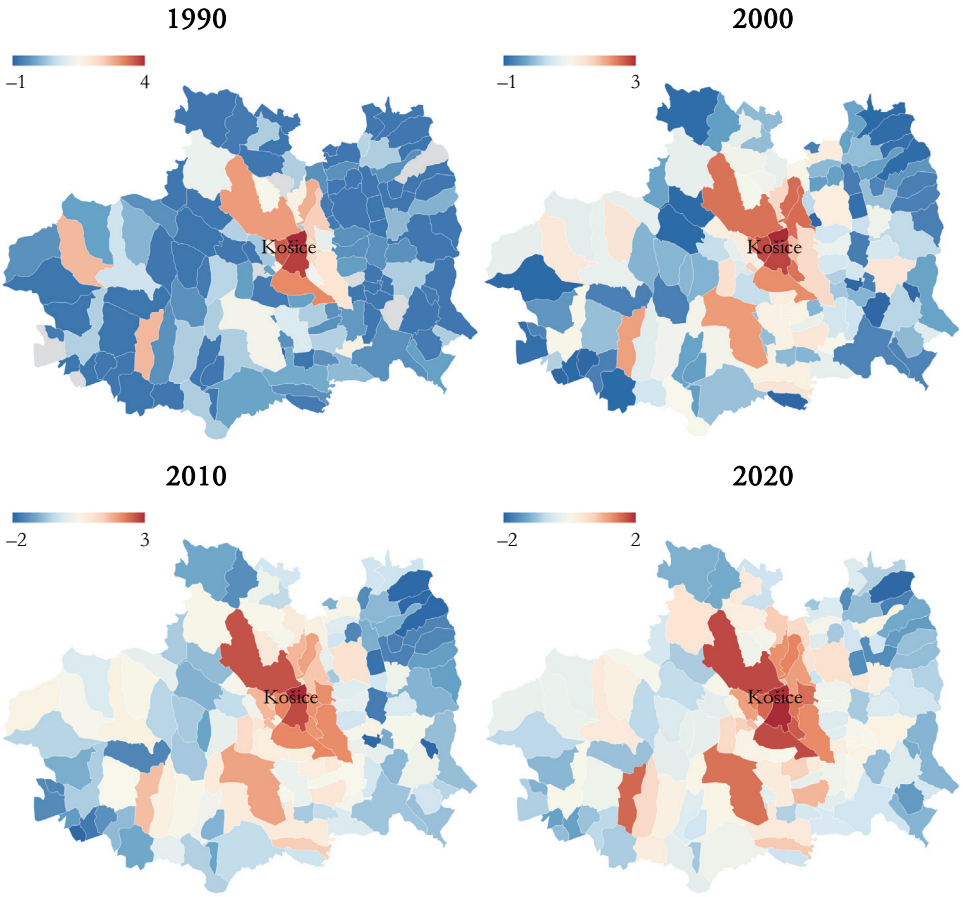


Figure A3

Economic complexity variation between the city of Košice and surrounding areas in the Košice-okolie district



Note: The variation is depicted using a continuous linear scale color gradient from blue (representing lower ECI values) to red (representing higher ECI values). Map data: ZBGIS (2023).

Figure A4

Košice and Košice-okolie

Figure A5

Territorial differences in economic complexity between 22 urban districts and 112 communities in Košice & Košice-okolie: Time series of Moran's index I (MI)

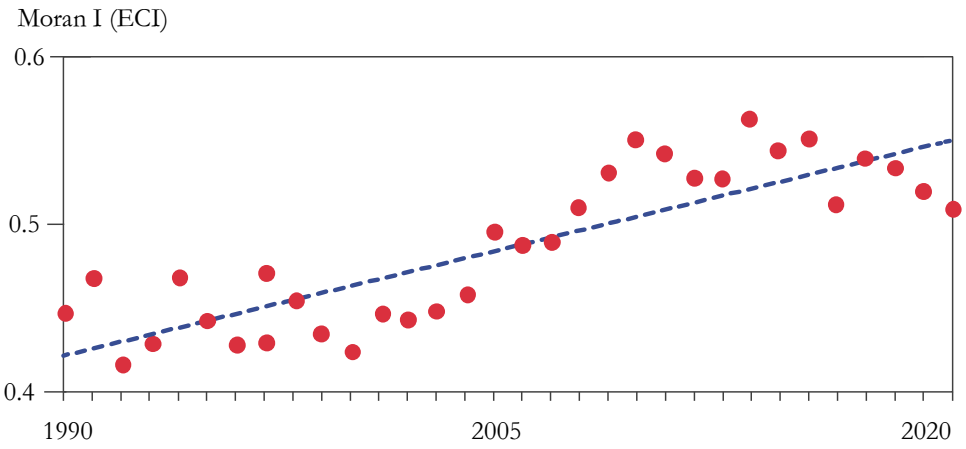
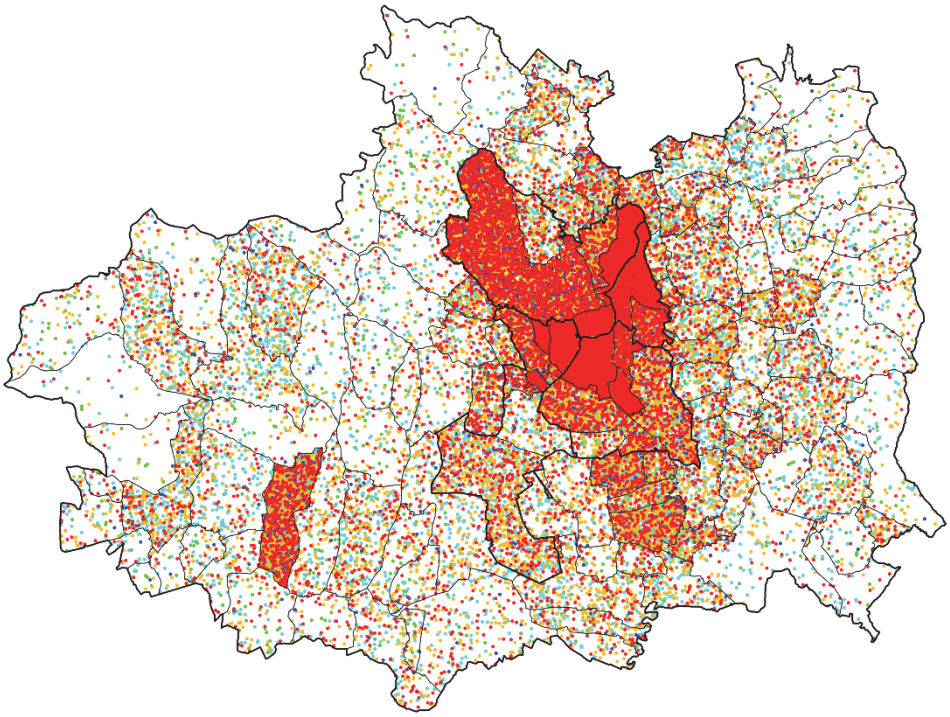


Figure A6

Urban and sectoral gradient of enterprises in Košice in January 2022



1 dot = 1 enterprise registered in communities and city neighborhoods in five categories combining multiple NACE sections in the following way:

- Primary sector – A, B
- Secondary sector – C, D, E, F
- Commercial services sector – G, H, I, K, L
- Public services sector – O, P, Q
- Knowledge-based and creative services sector – J, M, N, R, S, U

Note: Dots overlay in central city neighborhoods, and only higher categories appear on the map's "surface". Enterprise identification comes from the Register of Financial Statements, Ministry of Finance of the SR (2022).

REFERENCES

ALBERTI, M.–MARZLUFF, J. M.–SHULENBERGER, E.–BRADLEY, G.–RYAN, C.–ZUMBRUNNEN, C. (2003): Integrating humans into ecology: Opportunities and challenges for studying urban ecosystems *BioScience* 53 (12): 1169–1179. https://doi.org/10.1641/0006-3568(2003)053[1169:IHIEOA]2.0.CO;2

ANSELIN, L. (1995): Local indicators of spatial association – LISA *Geographical Analysis* 27 (2): 93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

BODIN, Ö.–ALEXANDER, S. M.–BAGGIO, J.–BARNES, M. L.–BERARDO, R.–CUMMING, G. S.–DEE, L. E.–FISCHER, A. P.–FISCHER, M.–MANCILLA GARCIA, M.–GUERRERO, A. M.–HILEMAN, J.–INGOLD, K.–MATOUS, P.–MORRISON, T. H.–NOHRSTEDT, D.–PITTMAN, J.–ROBINS, G.–SAYLES, J. S. (2019): Improving network approaches to the study of complex social-ecological interdependencies *Nature Sustainability* 2 (7): 551–559. https://doi.org/10.1038/s41893-019-0308-0

COLBY, C. C. (1933): Centrifugal and centripetal forces in urban geography *Annals of the Association of American Geographers* 23 (1): 1–20.

DURANTON, G.–PUGA, D. (2000): Diversity and specialisation in cities: why, where and when does it matter? *Urban Studies* 37 (3): 533–555. https://doi.org/10.1080/0042098002104

FARMER, J. D.–FOLEY, D. (2009): The economy needs agent-based modelling *Nature* 460 (7256): 685–686. https://doi.org/10.1038/460685a

FLORIDA, R. (2002): *The rise of the creative class* Basic Books, New York.

FLORIDA, R. (2005): The World is spiky. Globalization has changed the economic playing field, but hasn't leveled it *Atlantic monthly* 296 (3): 48.

FRIEDMAN, T. L. (2005): *The world is flat: A brief history of the twenty-first century* Macmillan.

GETIS, A.–GETIS, J. (1966): Christaller's central place theory *Journal of Geography* 65 (5): 220–226. https://doi.org/10.1080/00221346608982415

GIBSON, C.–LUCKMAN, S.–WILLOUGHBY-SMITH, J. (2010): Creativity without borders? Rethinking remoteness and proximity *Australian Geographer* 41 (1): 25–38. http://dx.doi.org/10.1080/00049180903535543

HAUSMANN, R.–HIDALGO, C. A.–BUSTOS, S.–COSCIA, M.–SIMOES, A. (2014): *The atlas of economic complexity: Mapping paths to prosperity* Mit Press.

HIDALGO, C. A. (2021): Economic complexity theory and applications *Nature Reviews Physics* 3 (2): 92–113. https://doi.org/10.1038/s42254-020-00275-1

HUDEC, O.–REMOALDO, P. C.–URBANČÍKOVÁ, N.–CADIMA RIBEIRO, J. A. (2019): Stepping out of the shadows: Legacy of the European Capitals of culture, Guimarães 2012 and Košice 2013 *Sustainability* 11 (5): 1469. https://doi.org/10.3390/su11051469

IAMMARINO, S.–RODRIGUEZ-POSE, A.–STORPER, M. (2019): Regional inequality in Europe: Evidence, theory and policy implications *Journal of Economic Geography* 19 (2): 273–298. https://doi.org/10.1093/jeg/lby021

KÉZAI, P. K.–RECHNITZER, J. (2023): Performance of enterprises in cultural and creative industries in large Hungarian cities between 2008 and 2018 *Regional Statistics* 13 (1): 167–198. https://doi.org/10.15196/RS130108

LANZOLLA, G.–PESCE, D.–TUCCI, C. L. (2021): The digital transformation of search and recombination in the innovation function: Tensions and an integrative framework *Journal of Product Innovation Management* 38 (1): 90–113. https://doi.org/10.1111/jpim.12546

LAZZERETTI, L.–CAPONE, F.–BOIX, R. (2012): Reasons for clustering of creative industries in Italy and Spain *European Planning Studies* 20 (8): 1243–1262. https://doi.org/10.1080/09654313.2012.680585

LUX, G.–HORVÁTH, G. (eds.) (2018): *The Routledge handbook to regional development in Central and Eastern Europe* Routledge. https://doi.org/10.4324/9781315586137

MARTIN, R.–SUNLEY, P. (2010): The place of path dependence in an evolutionary perspective on the economic landscape. In: BOSCHMA, R.–MARTIN. R. (eds): *The handbook of evolutionary economic geography*. Edward Elgar Publishing. https://doi.org/10.4337/9781849806497.00010

MILLO, G.–PIRAS, G. (2012): Splm: Spatial panel data models in R. *Journal of statistical software* 47: 1–38. https://doi.org/10.18637/jss.v047.i01

MORETTI, E. (2012): *The new geography of jobs* Houghton Mifflin Harcourt, Boston, New York.

REHÁK, Š.–HUDEC, O.–BUČEK, M. (2013): Path dependency and path plasticity in emerging industries *Zeitschrift für Wirtschaftsgeographie* 57 (1-2): 52–66. https://doi.org/10.1515/zfw.2013.0005

RODRÍGUEZ-POSE, A. (2018): The revenge of the places that don't matter (and what to do about it) *Cambridge Journal of Regions, Economy and Society* 11 (1): 189–209. http://doi.org/10.1093/cjres/rsx024

RODRÍGUEZ-POSE, A.–FITJAR, R. D. (2013): Buzz, archipelago economies and the future of intermediate and peripheral areas in a spiky world *European Planning Studies* 21 (3): 355–372. https://doi.org/10.1080/09654313.2012.716246

SCHAD, J.–LEWIS, M. W.–SMITH, W. K. (2019): Quo vadis, paradox? Centripetal and centrifugal forces in theory development *Strategic Organization* 17 (1): 107–119. https://doi.org/10.1177/1476127018786218

SMIT, A. J. (2011): The influence of district visual quality on location decisions of creative entrepreneurs *Journal of the American Planning Association* 77 (2): 167–184. https://doi.org/10.1080/01944363.2011.567924

ŠVEDA, M.–ŠUŠKA, P. (2020): *Suburbanizácia 2. Sondy do premien zázemia Bratislavy* Institute of Geography of the Slovak Academy of Sciences, Bratislava.

ŠEBOVÁ, M.–HUDEC, O. (2012): The ICT sector evolution in an industrial region of Slovakia *Ekonomický časopis* 60 (1): 65–82.

TAGAI, G.–BERNARD, J.–ŠIMON, M.–KOÓS, B. (2018): Two faces of peripherality: Labour markets, poverty, and population dynamics in Hungary and Czechia *Regional Statistics* 8 (2): 19–45. http://dx.doi.org/10.15196/RS080204

VAN DIJK, J.–FOLMER, H.–OOSTERHAVEN, J. (2019): *Regional policy: Rationale, foundations and measurement of its effects. In Handbook of regional growth and development theories* Edward Elgar Publishing. https://doi.org/10.4337/9781788970020.00036

INTERNET SOURCES

MINISTRY OF FINANCE OF THE SLOVAK REPUBLIC (2022): *Register účtovných závierok (Register of the financial statements)*. https://www.registeruz.sk (downloaded: February 2023)

VARGAS, M. (2022): *economiccomplexity: Computational Methods for Economic Complexity. R package version 1.4.0*. https://CRAN.R-project.org/package=economiccomplexity (downloaded: February 2023)

WEBSITES/DATABASES

[1] EUROPEAN COMMISSION (2022): *Geostat population grid dataset 2006, 2011, 2018*. https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography/geostat (downloaded: February 2023)

[2] EUROPEAN UNION, COPERNICUS LAND MONITORING SERVICE (2022): *Corine Land Cover 1990, 2000, 2006, 2012, 2018*. https://land.copernicus.eu/pan-european/corine-land-cover (downloaded: February 2023)

[3] FINSTAT (2022): *Databáza firiem a organizácií (Database of companies and organisations)*. https://finstat.sk (downloaded: February 2023)

[4] GEODESY, CARTOGRAPHY AND CADASTRE AUTHORITY OF THE SLOVAK REPUBLIC (GKÚ BRATISLAVA) (2022): https://www.geoportal.sk/sk/zbgis/na-stiahnutie/ (downloaded: February 2023)