

The nexus of a regional competitiveness and economic resilience: The evidence-based on V4+4 NUTS 2 regions

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Abstract: Economies have always been prone to economic downturns, industry shocks, currency crises, and the current COVID-19 epidemic crises, destabilising a region's economic growth trajectory and pattern. By re-establishing economic ties both inside and outside regions, regional economies that have been disturbed by a shock may transition to a new growth trajectory. We examined the idea of competitiveness and resilience in a regional development context to answer why one region is more susceptible to economic shock than others and the competitive advantages and disadvantages of V4+4 countries. This article highlights some of the core characteristics of regional competitiveness and resilience and gives a survey of the notion, main empirical results, and planning tasks concerning regional competitiveness and resilience. The idea of resilience is gaining greatness because of the COVID-19 crisis, and its importance is growing in research and economic policymaking. Ideas like "2020 made us stronger" and "resilience, tenacity, and the ability to bounce back" are obviously alluring during the current crisis. The COVID-19 problem, however, has decreased the main systems' shock resistance and caused failures to spread from one system to another. Thus, it is necessary to suggest a systems approach focused on resilience to have socio-economic systems ready for potential shocks. The paper's main topic is resilience-focused tactics, with a focus on the current European Union strategy. The European Union must strengthen its resilience considering the COVID-19 issue and the political agenda that is transition-driven in order to move forward or recover but emerge stronger. If policies are to be effective in the long run, an attitude responding to the systemic causes and impacts of big shocks is required.

Keywords: Economic shocks, regional development, V4+4 countries analysis, economic resilience, regional competitiveness index.

JEL Classification: C46, O18, O52, R10, R11.

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Introduction

Any territory's geographical map can be used to spot an unbalanced population distribution quickly. Instead of the less populated surroundings, these maps frequently show

minor, densely populated "nodal" points. Natural reasons can be used to explain why there is an uneven distribution of people and economic activity over space. Terrain configurations and climatic factors make some areas of the world

uninhabitable. On the other side, settlement expansion and development are facilitated by the fertile ground near water supplies. However, a significant portion of the pattern of the uneven spatial distribution of economic activity cannot be entirely attributable to geographical causes but rather to a variety of endogenous factors (De Bruyne, 2006). The attractiveness of a region for inflows of economic activity is determined by the socio-institutional framework. According to Danon (2014), the activity is unevenly dispersed throughout several territories because of several endogenous causes. Aspects of production that are adrift may migrate between sites because of these interregional variations. Territories might be seen as contending for the attraction and retention of economic activity in this environment if we suppose a finite set of factors of production with a marginal amount of mobility. The measure of success in this competition can be described as regional competitiveness according to Camagni (2002). In this context, a region characterised by the dominance of agglomerative forces over dispersive forces experiences a continuous inflow of mobile production inputs, indicating success. Conversely, an uncompetitive region faces the constant risk of losing footloose forces and experiencing decline. The emphasis on regions stems from the growing recognition that they are the prime spatial units where economies of scale and knowledge generation occur simultaneously (Huggins, 2003). This leads to the conclusion that competition takes place among regions or sub-national areas rather than countries. A region is a good option since it has a uniform institutional framework, a similar economic and social structure, and is generally homogeneous. At the same time, it often does not discard country rights.

Thus, the region has recently emerged as a complex and challenging subject for economic research. Many spatial topics, particularly territorial or regional ones, are increasingly challenging competitiveness as the new economic geography enters the mainstream. According to Krugman (2003), it is conceivable to talk of regional competitiveness as a region's ability to draw in and hold on to mobile factors of production, a topic that is becoming more and more significant in a global economy that is ever more integrated. Yet, this area of economic geography is still developing and lacks measurements that are generally recognised.

Multiple studies demonstrate that regions vary in their ability to effectively address the challenges posed by evolving global competition, influenced by changes in the global environment. Regional competitiveness has been heavily researched over the past few decades. But they fall short of offering a thorough justification and a suitable, transportable remedy. To support competitiveness, particularly for nations and regions, it is vital to establish the framework conditions for the growth of the infrastructure, human capital, technology, and effective markets that can assist draw in talent and investment. Being competitive also involves having the necessary preconditions to endure unforeseen external shocks or the capacity of a regional economy to withstand, absorb, or recover from such a shock. It is important to keep in mind that resistance to an economic shock does not always mean that the economy is stable and doing well in the long run. As practitioners of economic development have worked to understand the elements that influence an area's capacity to resist and recover from economic shocks, resilience has become a growing subject of research. Regional economic resilience has become a crucial area of study due to factors such as globalisation, rapid technological advancement, severe recessions, and man-made calamities. Regional variations exist in how these exogenous shocks and recovery mechanisms affect the economy. One of the key disadvantages that limit a region's ability to absorb an external shock is a lack of economic diversification, confirming the close interrelation of the competitiveness and resilience ideas.

The article aims at revealing mechanisms of interplay between competitiveness and resilience across regions by identifying the dynamics of competitiveness and resilience. The comparative approach helps us better understand the nexus of competitiveness and resilience, and therefore, the article's reasoning may offer valuable insights for future regional policies. Results show the ability of a region to offer an attractive environment for firms and residents to live and work. The section of the article dealing with regional competitiveness is based on the methodological approach in the form of composite index, and benchmark of regional competitiveness scores to highlight the changes over time. The section of the article dealing with regional resilience is based on an assessment of the economic resilience

of regions based on employment and gross domestic product.

Why is it so crucial to measure regional resilience and competitiveness? Because you cannot improve something if you cannot measure it (Drucker, 2004). The regions will find it easier to identify potential weaknesses and the key elements causing these weaknesses and, conversely, the strengths with the aid of a quantitative competitiveness and resilience score. In turn, this will help the areas catch up with the process. To do this, the article has employed a mixed-methods approach that has combined quantitative data analysis with qualitative fieldwork. The article provides several associated conceptual questions that form the foundations for the work undertaken. Based on the evaluation of the relevant literature, the research hypotheses of the presented work were defined:

H1: A significant link between competitiveness and resilience exists in a regional context.

H2: The highest level of resilience characterises the most competitive regions.

Finally, it should be highlighted that evaluations have a strong quantitative component, and the concepts of the supplied issues are, in this sense, more statistical than analytical or methodical. Yet, background information also includes theoretical and philosophical elements. At the article's core is the application of selected quantitative methods to study geographical elements of competitiveness and resilience using data in detailed regional divisions.

The sections of the article are structured as follows. Section 1 provides a comprehensive survey of regional competitiveness and economic resilience and introduces the main aspects of theoretical and empirical issues. Section 2 introduces the methodology adopted to study regional competitiveness and economic resilience. Section 3 presents the empirical findings of the quantitative analysis of regional competitiveness and economic resilience. Section 4 helps to bring everything together and ensures a comparative study of both concepts, providing a concluding summary of the main findings. Finally, the conclusions put the topic into the context of COVID-19 reality and the reality of the Russian Federation invading Ukraine; both exogenous types of shocks are clearly and undoubtedly associated with the search for a strategy to be a more resilient economy

based on competitive advantages, eventually searching for new competitive advantages.

1. Theoretical background

Economic downturns, sector shocks, and currency crises – all of which can disrupt the trajectory and pattern of regional economic growth – have long been a threat to economies. By re-establishing economic ties both within the region and with other regions, a regional economy that has been shaken by a shock may start on a new growth path. Regions are increasingly taking the lead in shaping the global economy. One of the most noticeable characteristics of regional economies is frequently the existence of clusters or geographic concentrations of related industries. The relocation of production operations to locations with better conditions undermines current economic fundamentals. The regionalisation of public policy also affects the emphasis on regions in the European Union (EU) in accordance with the subsidiarity concept because of a change in governing and the coordination of operations at the regional level. Governmental circles have been more interested in the regional underpinnings of national economies and in creating novel regionally-oriented policy interventions to help boost regional competitiveness and, subsequently the national economy. As a result, regions become more crucial to the economic growth of nations. We examined the idea of competitiveness and resilience in a regional development context to answer why some regions are more susceptible to economic shock than others, as well as the advantages and disadvantages of each region's competitive environment.

1.1 Concept of competitiveness

Although the idea of competitiveness is one of the most common in economics, it is not well defined. Hence, there is no accepted definition of it. The level at which the concept of competitiveness is described is crucial; typically, the micro and macro levels are strictly interrelated. According to the World Economic Forum (WEF), one of the most important definitions of competitiveness is the collection of institutions, policies, and variables that affect productivity (Schwab & Porter, 2007). The WEF defines competitiveness at macro (country) and micro (company) levels. The relationship between the two levels is clear: while a stable macro-economic environment promotes opportunities

for wealth creation, it does not produce wealth independently. The ability to produce goods and services while utilising capital, human capital, and natural resources is what generates prosperity. Productivity, on the other hand, is defined by the microeconomic capacity of the economy, which is basically decided by the efficacy and quality of the firms (Martin et al., 2006). The implicit comparison between corporations and governments has drawn a lot of ire because a country cannot go out of business, and rivalry between nations can be beneficial to both. Many scholars, including Krugman (2003), acknowledge that productivity – the value of goods and services produced by a country per unit of human, capital, and natural resources – is the best way to define competitiveness. A nation's ability to support high wages, a robust currency, compelling returns on investment, and a high standard of living is due to its productivity (Porter, 2003). Today, one of the most closely watched aspects of national economies is their level of competitiveness, which is increasingly being used to measure their prosperity, welfare, and living standards. Although it has quickly reached the regional level, the idea of competition is also debatable. Regional competitiveness cannot be classified as a macro or a micro idea. A region is more than just a group of companies or a smaller version of a nation (Gardiner et al., 2004). According to Meyer-Stamer (2008), a territory's competitiveness can be assessed by looking at its ability to generate significant and rising revenue streams and raise the standard of living for its citizens.

The academic interest in the issue of regional competitiveness has grown more and more, summing up many publications (Grassia et al., 2022). The multifaceted nature of regional competitiveness makes it challenging to provide a definition as well as a context for measuring and subsequently evaluating. The debate concerning different dimensions and topics or themes related to competitiveness, or the "new competition," influences the diverse strategies and actions that can be carried out for improving the socio-economic conditions of a given area, especially regions (generally, territorial competitiveness of countries, regions or cities). The formulation of regional competitiveness thus affects the current and relatively new debate considering all possible contexts affecting regions and their performance, e.g., Garcia-Alvarez-Coque et al.

(2021) differ in three conceptions of regional competitiveness (regions as sites of specialisation, regions as a source of increasing returns, regions as hubs of knowledge and economic trade). The heterogeneity of regional competitiveness definition is a widely discussed theme and can be triggered by several factors. This source of differentiation, regarded as the intersection of socio-economic and cultural components, can be the key to success for many regions (Dagiliene et al., 2020; Lavrinenko et al., 2019; Pietrzak et al., 2017; Sagiyeva et al., 2018; Zeibote et al., 2019). In contrast to the WEF definition, which strongly emphasises productivity, this definition is exclusively centred on the advantages for residents. Therefore, regional competitiveness can be characterised as the capacity to provide a desirable and sustainable environment for enterprises and people to live and work. Such a description is offered by Dijkstra et al. (2011) and includes the perspectives of both firms and people. According to the Sixth Progress Report on Economic and Social Cohesion (European Commission, 2009), despite the likelihood of significant variance in the competitiveness of the firms located within the region, it is challenging to incorporate into a regional competitiveness index (RCI) the assumption that every region has standard elements that influence and drive the competitiveness of all the enterprises placed there. The workforce's skills, the efficiency and justice of the institutions, and the physical and social infrastructure should all be included in this list. The EU promotes competitiveness by implementing policies that improve the climate for doing business, foster innovation, modernise the industrial base, and provide varied levels of sectoral aid and support for structural change through the coordination of economic policy. Such assistance is provided through several programs run by the European Commission (EC) and the European Structural and Investment Funds (ESIF).

1.2 Concept of resilience

The economic resilience of regions has been defined by many authors (e.g., Navarrete, 2011; Pelling & Manuel-Navarrete, 2011). Broadly defined regional resilience is mentioned in the literature describing the effects of natural or anthropogenic catastrophes (Holling, 2002; Pelling & Manuel-Navarrete, 2011; Sutton et al., 2023). The origin of the concept of regional

resilience is stamped mainly from environmental studies that studied the adaptation of ecosystems (Hill, 2012). The concept is used by a range of scientists, from economic geographers to regional analysts and economists. We could mainly mention Pendall et al. (2010) and Foster (2007). Among the Czech scientists, we can mention Kraft et al. (2011) and Koutský et al. (2012). Martin and Sunley (2015) point out that the existence of many different definitions is confusing but that it is caused by adopting the idea of resilience from various scientific disciplines. Above all possible definitions, we must stress the definition of so-called engineering resilience. This approach describes resilience as the resistance of the economic system to disturbance, and the main character is the speed of recovery of the economic system.

The engineering resilience approach means that the less the region is affected by disturbance, the sooner it returns to its steady state and the more resilient the region can be. This interpretation assumes that the economic system has only one steady state or equilibrium, which some scientists see as non-realistic; the approach of ecological understanding instead of seeing the possibility of many steady-states or equilibrium. These steady states can be reached after external shocks. Disturbances and shocks can move the system from one equilibrium to another (Fingleton et al., 2012). According to the ecological approach, the resilient economic system adapts by either resuming or improving its long-run equilibrium growth path (Gong et al., 2020; Simmie & Martin, 2010). That is an attribute of complex adaptive systems (Balland et al., 2015; Simmie & Martin, 2010). According to the ecological approach, resilience is an evolutionary process of continual adjustments. Many other definitions claim that resilience means the capacity of the system to resist, withstand or quickly recover from negative exogenous shocks and disturbances and to renew, adjust or re-orientate from these shocks (Bigos et al., 2013). From a methodological point of view, we must conclude that many studies focusing on economic crisis use the first (engineering) approach due to its simplicity and methodological clarity. The same approach will also be used in this study. Above all, it is important to add that the shock response mechanism depends on regional actors and forms not only region-specific but also sector-specific patterns of response and adaptation (Martin & Sunley,

2015; Wang & Ge, 2023). Not only internal actors but also exogenous economic actors and cross-regional relationships strongly influence regional resilience. The importance is seen in international moves of interacting agents that exploit flexible spatial configurations and power relations (Hou et al., 2023; Pike et al., 2010).

2. Approaches and methods to measuring competitiveness and resilience

The complexity of defining competitiveness and resilience leads to difficulties in their measurement. Evaluation is no less complicated than the definition and understanding of both concepts. Creating an evaluation system is complicated by the heterogeneity of territories and its approach to the original idea of competitiveness and resilience. There is a space for alternative techniques because of the lack of a mainstream view of the evaluation of concepts. There are several approaches for analysing regional economies, and most of them have drawbacks, particularly when it comes to identifying appropriate indicators and weighting schemes (if needed and required). Currently, quantitative and qualitative development at the regional level increases socio-economic attraction and creates new opportunities for overcoming disparities, increasing competitiveness and boosting the resilience of regions.

2.1 Measuring competitiveness

Considering the different positions that emerged from the literature review, it is logical that this also evokes developments in approaches to measuring competitiveness. Afterwards, “competitiveness” is a relative term that requires comparison with others; areas are compelled to continuously monitor and periodically benchmark what the competition is doing to determine where the best practice or best offer is located. The goal of competitiveness has, therefore, taken on major relevance for policymakers. Interest in assessing regional competitive performance and developing measures to promote and enhance competitiveness has increased within government circles. In fact, the European Commission has enthusiastically promoted regional competitiveness as a policy objective. It has gained notoriety in the United Kingdom, where the national government’s policy pronouncements now emphasise pursuing regional competitiveness. Due to this, there

is now a lot of interest in constructing composite indices (CIs), enabling the comparison of regions based on individual scores and ranks (Berger, 2011). CIs can be beneficial for illustrating regional differences in particular economic situations. More and more scholars have studied the benchmarking of locations over the past few years. Numerous reputable studies that use a standard methodology measure competitiveness at the national level. Global competitiveness index (GCI), included in the World Economic Forum's (WEF) Global Competitiveness Report (GCR), and the Institute for Management Development's (IMD) World Competitiveness Yearbook (WCY) are by far the most significant and well-known indices at the national level. The GCI is the most often used index and includes many competitiveness-related factors. More recently, particularly in the EU, attempts have been made to expand the national analysis at the regional level.

The Atlas of Regional Competitiveness (Eurochambers, 2007), which reflects the significance of the areas at the EU NUTS 2 level being recognised internationally, provides a more complete geographical definition of competitiveness. The variables are not, however, effectively combined by the approach into a composite index. Some European nations have worked hard to develop national indicators of regional competitiveness, such as Croatia (UNDP, 2008), the UK (Huggins & Izushi, 2008), Finland (Huovari et al., 2001), Lithuania (Snieska & Bruneckienė, 2009), in the Visegrad Four Countries or their NUTS 2 regions (Melecký & Skokan, 2011) and the Czech Republic (Žižka, 2013). The most accessible and also the most popular group of approaches today are composite indices. We can mention the works of D'Urso et al. (2019) or González Catalán (2021). Even though regions receive mixed reviews compared to other regions in various competitiveness rankings studies, a simple and feasible conclusion can be drawn from these results and can be considered as the relevant background for sophisticated benchmarking and comparison (Rodríguez-Díaz et al., 2021). The literature's most widely acclaimed index is seemingly the regional competitiveness index constructed for the EU by Annoni and Kozovska (2010) and subsequently enhanced, enlarged and updated by Annoni and Dijkstra (2013), Annoni et al. (2017), Annoni and Dijkstra (2019) and Dijkstra et al. (2023). RCI includes regions

at the EU NUTS 2 level. These studies coincide with the EC reports on economic, social and territorial cohesion. RCI's extensive territorial coverage and methodological rigour make it an excellent resource for endorsing the European Commission's policies.

2.2 Measuring resilience

Measuring regional employment, regional output, and other factors (such as regional wages, regional labor productivity, or regional investments) is the suggested method for evaluating regional economic resilience (ESPON, 2014). Regional products or employment at the regional level are the most common basis for quantifying regional resilience. Due to the problematic determination of regional products, regional employment is often analysed (Simmie & Martin, 2010). However, both indicators have their advantages and disadvantages. A common drawback of both indicators is the inability to shield the impact of commuting.

The literature has used a variety of techniques to gauge economic resilience (Martin & Sunley, 2015; Modica & Reggiani, 2015). While some authors (Fingleton et al., 2012; Lagravinese, 2015) advocate the use of univariate indicators based on GDP per capita or employment rates to measure the concept of resilience, another strategy has been the development of composite indexes based on a variety of variables that may adversely affect the degree of economic vulnerability (Briguglio, 2014; Melecký & Staníčková, 2015; Modica & Reggiani, 2015; Svoboda & Cichá, 2015). There are many different approaches to calculating indices representing the region's sensitivity to the crisis in the literature. This article used an index based on GDP p.c. and employment calculated like % change between given years. Another possible approach to measuring a crisis's impact is comparing growth rates before and after the crisis. For this purpose, we employed beta coefficients of regional time series representing a growth rate of GDP p.c. and employment, respectively. The advantage of the beta coefficient compared to the geometrically calculated average growth rate stems from its robustness to possible extremal values at the time series' beginning and end. Indexes are based on NUTS 2 regional GDP p.c. and employment retrieved from Eurostat (2022). The first mentioned index was calculated for each region based on GDP p.c., resp. number

of employed persons according to ESPON (2014), Equation (1):

$$index_i = \left(\frac{y_{i,t+n}}{y_{i,t}} \right) \quad (1)$$

where: *index* – % change of GDP p.c. (thousands of employed persons); *y* – regional GDP p.c. (thousands of employed persons); *t* – number of basic year (year 2008 can be considered as the last year before the crisis); *n* – the length of the examined period in years; *i* – the number of region.

To evaluate the impact of the crisis, index was calculated for GDP p.c. between years 2008 and 2009 and for employment between years 2008 and 2011. The period for employment is intentionally more extended than in the case of GDP p.c. because of the lag in labor market development. The second index (regional category) was calculated for each region via two beta coefficients – one before and one after the crisis (Wooldridge, 2016; Equation (2)):

$$\beta = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sum_{i=1}^n (X_i - \bar{X})^2} \quad (2)$$

where: β – beta coefficient of regression equation calculated for each region within two six years-long periods; β_1 is calculated before the crisis (2001–2006) and β_2 is calculated after the crisis (2010–2015), years 2007–2009 are intentionally omitted due to abnormal GDP/employment growth/decline rate; \bar{X} and \bar{Y} – the average of the X_i and Y_i , respectively; X_i stands for time and Y_i for regional values of GDP p.c./thousands of employed persons; *n* – the number of examined values in each time series.

Based on beta coefficients, regions were classified according to rules in Tab. 1 into four categories:

Category 1: Regions with relatively higher growth rates in both periods.

Category 2: Regions with relatively higher growth rate only in 2010–2015 (after crisis).

Category 3: Regions with relatively higher growth rate only in 2001–2006 (before crisis).

Category 4: Regions with relatively lower growth rates in both periods.

Tab. 1: Regional categories according to resilience point of view

Category	Rule	Description
1	$\beta_1 > \text{median of } \beta_1$, and $\beta_2 > \text{median of } \beta_2$	The pre-crisis growth rate and post-crisis growth rate above the median
2	$\beta_1 \leq \text{median of } \beta_1$, and $\beta_2 > \text{median of } \beta_2$	The pre-crisis growth rate below the median (or equal to median rate) and post-crisis growth rate above the median
3	$\beta_1 > \text{median of } \beta_1$, and $\beta_2 \leq \text{median of } \beta_2$	The pre-crisis growth rate above the median and post-crisis growth rate below the median (or equal to median rate)
4	$\beta_1 \leq \text{median of } \beta_1$, and $\beta_2 \leq \text{median of } \beta_2$	Pre-crisis and post-crisis growth rates below the median (or equal to median rate)

Source: own

3. Results of competitiveness and resilience

The Visegrad Group (V4) is the focus of the empirical analysis's geographic coverage, reflecting the efforts of the Central European countries to cooperate in several areas of shared interest as part of the integration of all of Europe. The nations of Czechia (CZ), Hungary (HU), Poland (PL), and Slovakia (SK) have long been a part of a unified civilisation

that shared common cultural and intellectual values as well as roots in various religious traditions. These nations want to protect and further build this civilisation. The participating countries perceive their cooperation as a challenge and its success as the best proof of their ability to integrate into such structures as the EU (Visegrad Group, 2019). For this purpose, V4 cooperates with other regional bodies, as well as with single countries in the region and beyond on an ad-hoc

or regular basis, which made the V4+4 format (V4 + Bulgaria (BG), Croatia (HR), Romania (RO) and Slovenia (SI)). All these countries belong to the group of so-called “new” EU Member States or into the EU13 group, i.e., countries that joined the EU in 2004 (Czechia, Hungary, Poland, Slovakia and Slovenia), 2007 (Bulgaria and Romania), and 2013 (Croatia). These are countries that are net recipients of the EU budget and benefit significantly from ESIF for the overall development of their territory. Due to the EU Cohesion Policy and the setting of the funds’ distribution, development is essential. Evaluating competitiveness and resilience is crucial for policymakers to identify regional strengths and weaknesses and to develop targeted regional development strategies that prioritise necessary investments in areas requiring improvement. The investigated territory analysis is based on the classification of EU NUTS (Nomenclature of Territorial Units for Statistics). The empirical research primarily concentrates on NUTS 2 regions, which are administrative or statistical regions that do not consider functional economic connections. Geographical coverage of empirical analysis consists of 53 NUTS 2 regions, i.e., 8 NUTS 2 CZ, 7 NUTS 2 HU, 16 NUTS 2 PL, 4 NUTS 2 SK, 6 NUTS 2 BG, 2 NUTS 2 CR, 8 NUTS 2 RO, 2 NUTS 2 SI.

3.1 Results of competitiveness

The RCI offers a distinctive policy instrument to monitor and evaluate the competitiveness of every NUTS 2 region within the European Union. RCI offers the first broad picture of the situation of regions, recognising the cross-regional comparison among the EU Member States. According to authors (Annoni & Dijkstra, 2013, 2019; Annoni et al., 2017; Annoni & Kozovska, 2010), RCI enables the expansion of conventional competitiveness research to include viewpoints from both firms and residents, taking into account both economic performance and individual well-being. These factors have been chosen following the EC’s definition of competitiveness for RCI, a region’s capacity to provide a desirable and sustainable environment for businesses and citizens to live and work in.

The main goal of RCI calculation has been to keep it straightforward, understandable to non-statisticians, and consistent (Annoni & Kozovska, 2010). Consequently, the final

RCI is constructed through a sequential aggregation process. Initially, the scores for each dimension of the RCI or within each pillar are determined by taking a simple arithmetic average of the normalised and converted indicators. In the subsequent stage, the arithmetic means of the dimension scores are calculated to obtain the scores for the three classes of competitiveness dimensions, namely basic, efficiency, and innovation. Standardised (z-scores) indicator values were utilised to create RCI sub-scores for each pillar. The sub-indices (scores) at the pillar class level are then computed by averaging the relevant sub-scores. In order to construct a sub-index for each of the three pillar classes (basic, efficiency, and innovation), the pillar scores for each class group are simply averaged. For each region i , the sub-scores allotted with the dimension classes are:

$$RCI_{basic}(i) = \frac{1}{5} \sum_{j=1}^5 \text{score}(i, j) \quad (3)$$

Score (i, j) is the score allotted to region i for dimension j ; RCI_{basic} presents sub-index of RCI for i -th region; i is V4+4 NUTS 2 region; $i \in \{1 = \text{BG31}, \dots, 53 = \text{SK04}\}$; j is appropriate competitiveness pillar for the sub-dimension index’s RCI_{basic} ; $j \in \{1 = \text{institutions}, 2 = \text{macro-economic stability}, 3 = \text{infrastructure}, 4 = \text{health}, 5 = \text{quality of primary and secondary education}\}$.

$$RCI_{efficiency}(i) = \frac{1}{3} \sum_{j=6}^8 \text{score}(i, j) \quad (4)$$

Score (i, j) is the score allotted to region i for dimension j ; $RCI_{efficiency}$ presents sub-index of RCI for i -th region; i is V4+4 NUTS 2 region; $i \in \{1 = \text{BG31}, \dots, 53 = \text{SK04}\}$; j is competitiveness pillar important to sub-index dimension $RCI_{efficiency}$; $j \in \{6 = \text{higher education and training and lifelong learning}, 7 = \text{labour market efficiency}, 8 = \text{market size}\}$.

$$RCI_{innovation}(i) = \frac{1}{3} \sum_{j=9}^{11} \text{score}(i, j) \quad (5)$$

Score (i, j) is the score allotted to region i for dimension j ; $RCI_{innovation}$ presents sub-index of RCI for i -th region; i is V4+4 NUTS 2 region; $i \in \{1 = \text{BG31}, \dots, 53 = \text{SK04}\}$; j is pillar of

competitiveness compatible with dimension of sub-index $RCI_{innovation}^j$: $j \in \{9 = \text{technological readiness}, 10 = \text{business sophistication}, 11 = \text{innovation}\}$.

In the final step, RCI score is determined as a weighted average of three sub-scores:

$$RCI(i) = w_{basic} RCI_{basic}(i) + w_{efficiency} RCI_{efficiency}(i) + w_{innovation} RCI_{innovation}(i) \quad (6)$$

$$w_{basic} + w_{efficiency} + w_{innovation} = 1 \quad (7)$$

$$w \in \langle 0,1 \rangle \quad (8)$$

where: $RCI_{(i)}$ gives a weighted composite index RCI for i -th region; w is normalised weight of i -th region for j -th competitiveness pillar reflecting the pertinent sub-index.

The three sub-indices are combined into the final RCI score using a set of weights determined by the region's level of development. RCI adopts the WEF methodology for final aggregation, wherein GCI takes a country's stage of development (SoD) into account and gives various weighting schemes to different pillars (Schwab & Porter, 2007). A similar strategy is used for RCI since some variation in the EU NUTS 2 regions' developmental stages is anticipated. The set of weights used to combine the sub-indices is determined by the regions' GDP-based medium, intermediate, and high stages of development, as well as two transitional phases. For detailed information about SoD, see Annoni and Kozovska (2010), Annoni and Dijkstra (2013), Annoni et al. (2017), and Annoni and Dijkstra (2019).

A region's socio-economic situation changes as it develops, and other factors start to weigh more heavily on the level of regional competitiveness. Because of this, the greatest method to help less developed regions catch up is different from the best way to make more developed regions more competitive.

RCI accepts both favourable and unfavourable scores. A region is competitive when it has a positive score, whereas a region is not competitive when it receives a negative value. There is an expected level of similarity across the V4+4 countries, but the RCI results highlight significant variances in the level of economic development among regions within and between nations. The RCI exhibits a polycentric structure in most of the examined countries,

characterised by the presence of significant capital cities and metropolitan areas. Like competitive regions surround certain capital areas, less competitive regions cover many capital regions. Significant differences exist between and within nations in the spatial distribution of competitiveness. Results from RCI editions reveal a polycentric trend, with extensive metropolitan areas and capital regions ranking the highest on the index. Competitiveness has usually stayed steady when comparing RCI versions. High within-country variances were frequently seen as a result of the capital region performing much better. Most of the top regions in every RCI edition are home to capital cities or sizable metropolises, contributing to the region's increased competitiveness. These regions are mainly in the Czech, Slovak, and Slovenian countries. At the other end of the spectrum, especially in Bulgaria and Romania, we discover several places that are regrettably consistently the lowest achievers. When comparing the country ratings, i.e., when calculating the national averages of RCI values, the resulting ranking of the countries is sequential, i.e., from Slovenia, Czechia, Slovakia, Poland, Croatia and Hungary to Romania and Bulgaria.

Fig. 1 shows cartograms of RCI results in reference periods 2010, 2013, 2016 and 2019 and changes across editions. For the geographical distribution of RCI scores, as a rule, the positive orientation of the index score is relevant. The higher the score, the higher (better) the level of competitiveness, and vice versa. The results of RCI are highlighted by the traffic light method. The range of colours of this method changes from dark shadows of red to dark shades of green. Regions with higher RCI scores have a better level of competitiveness and are highlighted by the dark green – the higher the score, the darker the shades of green. The overall pattern is not so different from the editions.

3.2 Results of resilience

The results of the economic resilience analysis are presented by the indicators derived from regional GDP p.c. and regional employment indexes (see cartograms in two columns of Fig. 2 – Part 1). The top cartogram in the first column shows the regional GDP p.c. change indicator during the recession (percentage of GDP p.c. difference between 2008 and

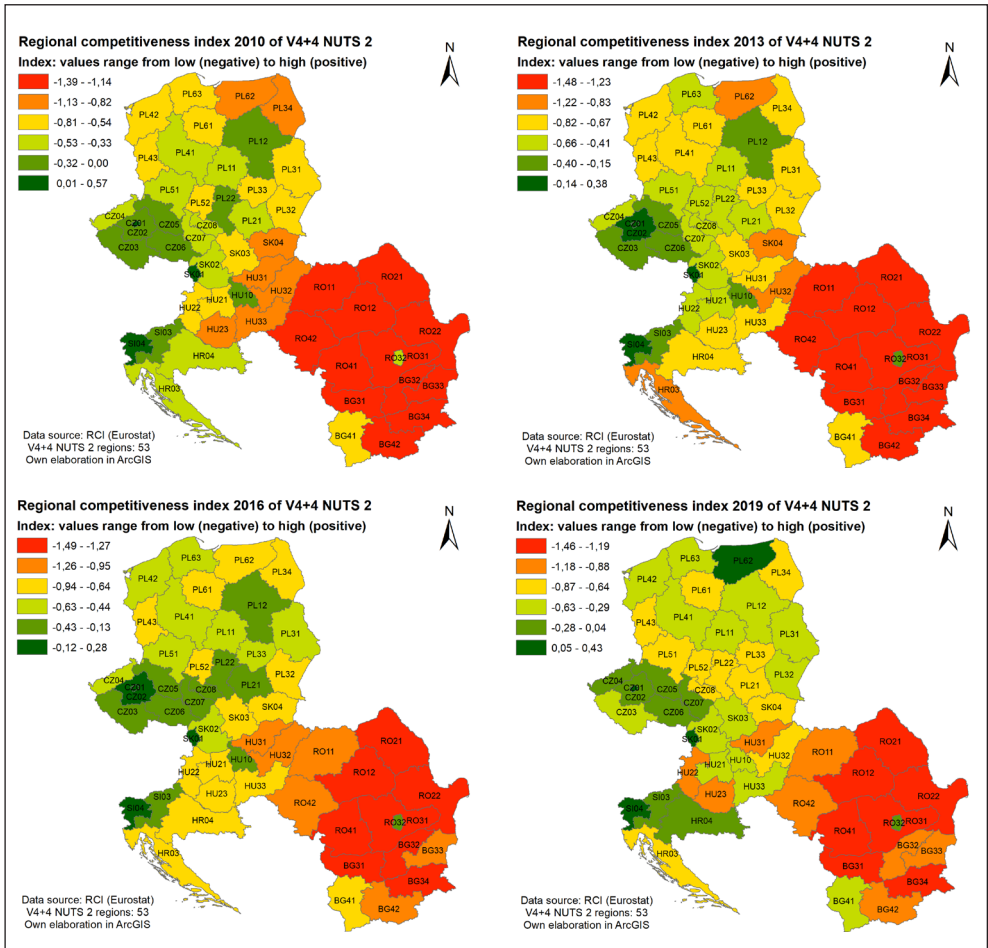


Fig. 1: RCI results

Source: own (in ArcGIS 10.5.1 (2022))

2009). Based on these results, it can be concluded that most of the V4+4 regions recorded declines in GDP p.c. The main exceptions were some of the Polish regions. The bottom cartogram in the first column (Fig. 2 – Part 1) shows the regional change in employment during the recession. The cartogram describes the percentage change in regional employment between 2008 and 2009. The situation here is very similar to the previous cartogram. Most of the V4+4 regions recorded a decline in employment. The exceptions included twelve regions of Poland, two regions of Czechia

(CZ01, CZ02), one in Hungary (HU23), and four regions in Romania. The above cartograms can be compared to the next cartograms – the second column (Fig. 2 – Part 1) and first column (Fig. 2 – Part 2), i.e., four cartograms: changes in GDP p.c. and employment for 2008–2016, 2008–2019 resp. In the case of percentage changes in GDP p.c., the results comply with similar studies focusing on regional convergences (regions with a relatively lower level of GDP p.c., e.g., regions of Romania achieve high growth rates and vice versa). The second column (Fig. 2 – Part 2) contains two cartograms

showing the regions belonging to the specified classes. These two cartograms show the economic crisis's impacts on GDP p.c. growth rate (upper cartogram), respectively, in terms of employment growth rate (lower cartogram). Categorical values 1 or 2 for GDP post-crisis growth rate above the median are represented mainly by the Czech and Polish regions. Categorical values three and four prevail in regions from Slovenia, Romania, and Bulgaria. In the case of Hungary, all categories are presented at approximately the same frequency. From the point of employment rate view (lower

cartogram in the fourth column), the categorical value one or two is represented mainly within the regions of Hungary, Slovakia, and Czechia. Categorical value three or four is presented in the case of Polish, Romanian, Bulgarian, and Croatian regions. Cartograms show that, as in the case of competitiveness analysis, resilience results show a level of heterogeneity over space (considerable differences in the strength of resilience of regional economies across and within countries). As in the case of RCI, a polycentric pattern with high economic resilience in the capital and metropolitan regions is shown

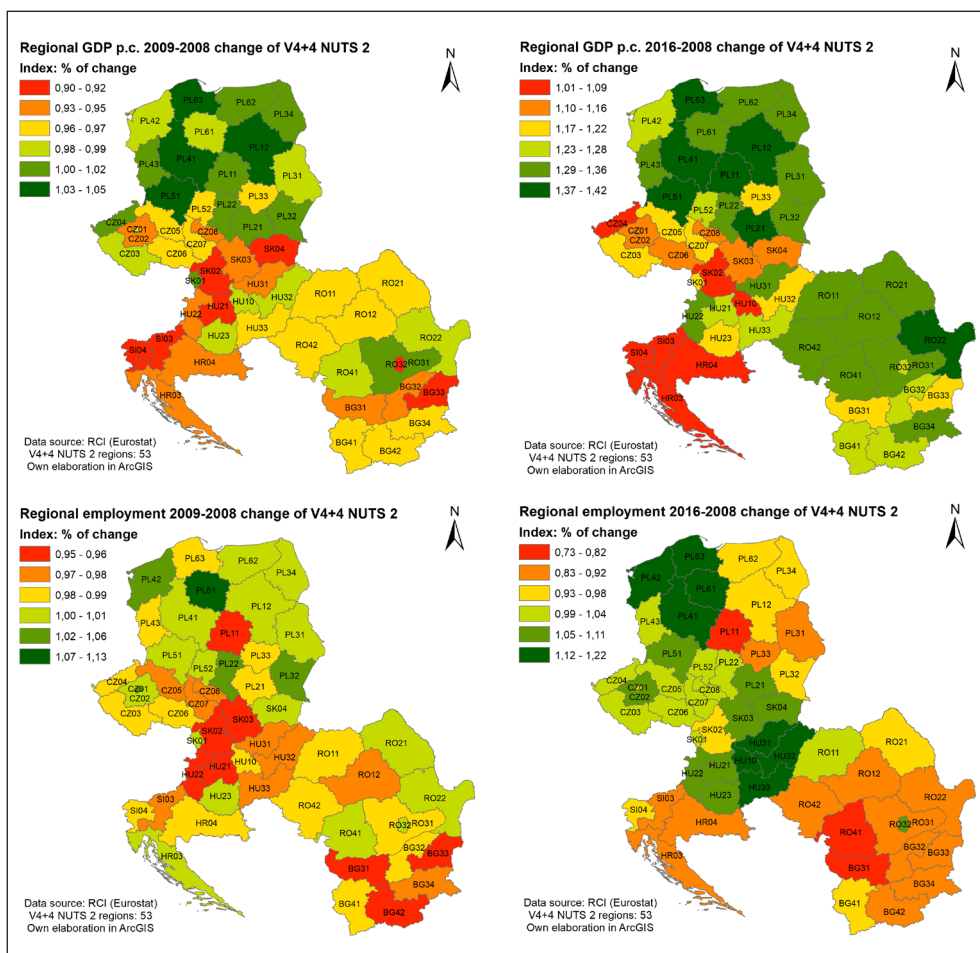


Fig. 2: Resilience results – Part 1

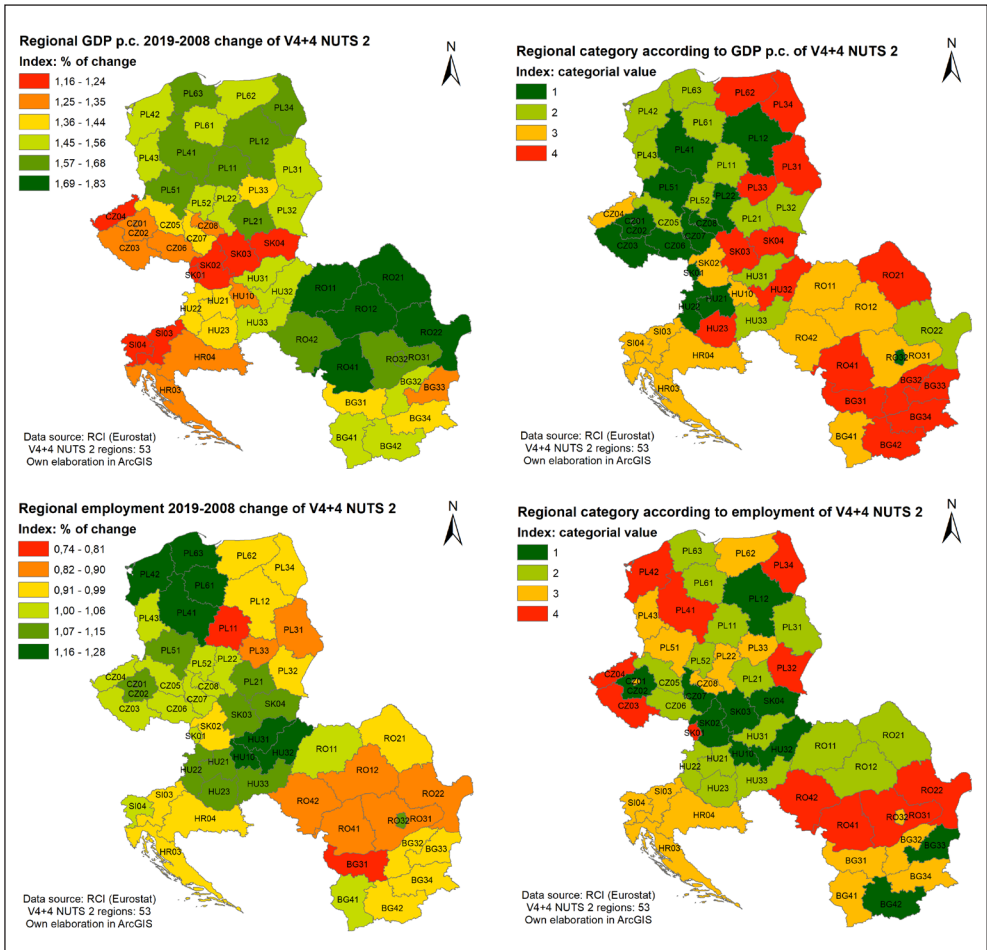


Fig. 2: Resilience results – Part 2

Source: own

in most countries under review. In addition, it should be noted that GDP p.c. resistance patterns show significant regional differences compared to employment resistance.

4. Comparison of empirical results of competitiveness and resilience

The V4+4 NUTS 2 regions' research on crisis resilience, particularly in relation to competitiveness, is managed within a theoretical and empirical scheme with the goals of identifying the effects of economic crises on regional economies, analysing structural and functional

determinants in regions, attempting to explain why some regions are more resilient than others, and identifying policies that support economic resilience. The purpose is thus to develop a measure of resilience to crisis, one that may be applied to regional data and compared with the level of competitiveness of the same sample of evaluated regions. Generally, such a measure can take either a positive or negative score on competitiveness and resilience issues. A positive score confirms resilience to crisis and a higher level of competitiveness, whereas a negative one confirms the absence

of resilience and a lower level of competitiveness. Research hypotheses were tested in two versions corresponding to two forms of resilience assessment (the first included the relationship of competitiveness and GDP p.c., and the second included competitiveness and employment). For the GDP p.c. related resilience indicator, the years 2008 and 2009 were chosen for the indicator's calculation. 2008 can be considered a year not yet affected by the economic crisis. The year 2009 corresponds to the year when a significant product decrease occurred in many EU regions. In the case of the employment-related resilience indicator, the years 2008 and 2011 were chosen for the indicator's calculation (the year 2011 corresponds to the most frequent occurrence of the bottom of the business cycle in several European regions). The correlation analysis showed that the first correlation pair (GDP p.c. related resilience indicator vs average regional RCI score from 2010, 2013, 2016, and 2019) is not statistically significantly correlated ($\alpha = 0.01$; $R = 0.12$). The second correlation pair (employment-related resilience indicator vs average regional RCI score)

showed a statistically significant positive correlation at the significance level of alpha 0.01 ($R = 0.59$). A statistically significant negative correlation was also found between the regional RCI scores in 2010 and the regional categorical value by regional GDP p.c. growth ($\alpha = 0.01$; $R = -0.58$). The results mentioned above can be considered as confirmation of the first hypothesis under investigation. Fig. 3 shows the relationship between the employment-related resilience indicator and the average regional RCI values.

A comparison of average RCI scores and employment change between 2011 and 2008 (Fig. 2) shows a statistically significant regression relationship ($R^2 = 0.29$; $\alpha = 0.01$) between the short-term adaptation to the negative economic shock and the long-term adaptation represented by the RCI indicator. At first glance, at the same time, there are a few regions that can be considered outlier values (e.g., the capital regions SK01 and CZ01). RCI score above the median level (-0.618) was most often achieved by regions of Czechia and regions of Poland – specifically, this threshold was reached by all NUTS 2 regions of Czechia,

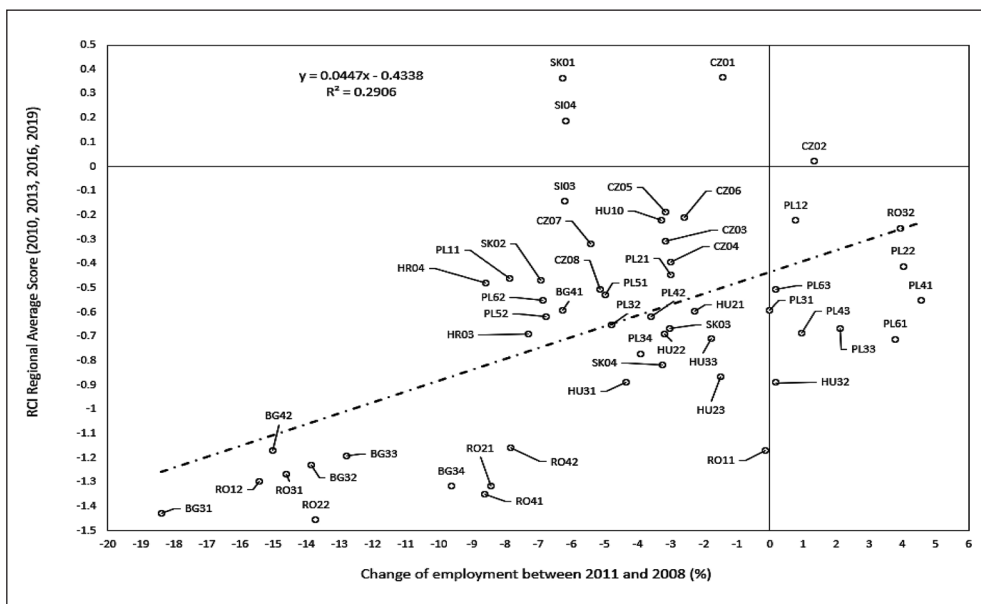


Fig. 3: Relationship between employment-related resilience and competitiveness

Source: own (based on RCI 2010, 2013, 2016, 2019; Eurostat (2022))

ten regions of Poland, two regions of Hungary (HU10, HU21), two regions of Slovakia (SK01, SK02) and Slovenia (SI03, SI0), one region of Croatia (HR04), one region of Romania (RO32) and one region of Bulgaria (BG41). The CZ regions (except CZ07 and CZ08), HU regions (except HU31), ten Polish regions, two Slovak regions (SK03, SK04), and two Romanian regions (RO11, RO32) recorded employment changes above the median level (-3.91%) within the examined period. Fig. 2 shows the central cluster of regions (all regions of Czechia, Poland, Slovakia, Hungary, and Croatia constitute the leading group). On the contrary, the second cluster of regions – in the lower left part of Fig. 2 – consists of most regions of Romania and Bulgaria.

Tab. 2 shows the results of comparing regional competitiveness and resilience for 53 regions. The first category comprises 15 regions with average RCI scores above the median and, simultaneously, with the percentage change in employment (Em) between 2011 and 2008 above the median. This category consists of very resilient and very competitive regions. 80% of all regions in this category are from Czechia and Poland. The second category consists of 11 regions with average RCI scores

above the median and simultaneously with employment percentage change below (or equal) to the index's median. These regions are showing relatively high competitiveness but less resilience in employment. 73% of these regions in the examined sample are from Hungary and Poland. The third category consists of 11 regions with RCI below (or equal) to the median and simultaneously with an employment rate more significant than the median. These are regions that have shown relatively high resilience but lower competitiveness. Most of these regions are Polish, and more than half consist of Slovak, Czech and Slovenian regions. The last (fourth) category consists of 16 regions with average RCI scores and employment rates below (or equal to) the median of the given index. These regions have shown relatively low competitiveness and relatively low resilience in employment. 38% of these regions were regions from Romania, and more than a quarter were regions from Bulgaria. The results mentioned above can be considered as confirmation of the second hypothesis under investigation.

A thorough understanding of geographical parallels and differences, as well as an understanding of the types of local and regional

Tab. 2: Comparing regional competitiveness and regional resilience

Country	Category				Total
	1 RCI > median and Em > median	2 RCI > median and Em ≤ median	3 RCI ≤ median and Em > median	4 RCI ≤ median and Em ≤ median	
BG	–	–	1	5	6
CZ	6	–	2	–	8
HR	–	–	1	1	2
HU	2	4	–	1	7
PL	6	4	3	3	16
RO	1	1	–	6	8
SI	–	–	2	–	2
SK	–	2	2	–	4
Total	15	11	11	16	53

Note: RCI – regional competitiveness index; Em – percentage change in employment between 2011 and 2008; BG – Bulgaria, CZ – Czechia, HR – Croatia, HU – Hungary, PL – Poland, RO – Romania, SI – Slovenia, SK – Slovakia.

Source: own (based on RCI 2010, 2013, 2016, 2019; Eurostat (2022))

responses are necessary to properly address the setting policy measures. Examining the impacts at the regional or local level rather than the national level presents a notable difficulty due to the limited availability of both quantitative and qualitative data. It is necessary to underline that the present survey has some limitations, mainly related (but not limited) to measuring based on indicators defined from the literature review and data creating approach itself. It is impossible to refer to a complete collection since each of the most common databases has strengths and weaknesses. Limitations of the research related to own calculations and subsequent results lie in the scope of reference period and data availability, as well as calculations based only secondary data from official statistical sources were analysed. Due to the time and scope of the article, only internal factors of regional issues were analysed. The assumption is that external factors for all regions are the same. To improve the quality of the analysis, it is possible to include also qualitative data from surveys that will better characterise some of the competitiveness aspects. But collection of such data will need extra resources and time. Considering all these aspects, the article might not precisely reflect the entire research activity on regional issues in the last years, but the results suggested potentially interesting insights into the topics debated by scholars and highlighted the future frontiers of the domain. Further development of this research will involve both the methodological side and the specific domain under investigation. At the same time, more in-depth analyses on specific issues of regional issues will be performed to improve the knowledge on themes currently debated in the reference literature, like for example the role of sustainability and innovation. From the point of view of the regional resilience of the regions, it is possible to perceive the limits of the research primarily in terms of the fact that each economic shock has its own specific course, and its impact cannot be generalised for all types of economic shocks.

Conclusions

To best target the priority areas and adapt to the changing environment, public investments must be carefully chosen by local and regional authorities and policymakers. By making investments in the advancement of human

capital, the modernisation of infrastructure, and the enhancement of business conditions, public intervention (particularly ESIF) can impact regional competitiveness. Since it is difficult to implement one-size-fits-all policies across all regions, it is crucial to capitalise on unique regional advantages and choose solutions that are appropriate for the various stages of development. However, to do this effectively, they need an adequate tool to monitor the impact of these measures, and the EC offers such a tool in the form of RCI. RCI presents a comprehensive view on the state of EU competitiveness at NUTS 2 regional level, balancing a variety of other important factors. Understanding how fiercely regions (territories/localities/areas or regions) compete, where this rivalry originates, and what factors influence territorial economic attractiveness are essential. With competitiveness as a starting point, comprehending territorial resilience issues enables us to consider the wealth generation of the territories, protect the welfare of all residents, promote sustainable economic growth, and manage economic shocks and decline in our territorial policies. Regional resilience, regional export orientation, business and corporate culture, regional institutional structure, and other aspects are clearly influenced by the type of state economic policy.

The 2020 epidemic has shaken every country, and no economy has been spared. With a strong territorial component, the COVID-19 issue has had a wide range of regional and local effects that have important implications for crisis management and policy responses. The COVID-19 pandemic has shown how important it is to build a robust system to deal with unanticipated shocks. The giant waves of the COVID-19 pandemic subsided no sooner than the Russian Federation invaded Ukraine. In addition to the humanitarian impact, the war significantly impacted European industry and trade. As a result, Europe is trying to wean itself off its dependence on Russian fossil fuels rapidly, and the prices of fuel and other (not only) energy raw materials are rising to record highs. At the same time, Putin's war in Ukraine is not replacing but further accentuating Europe's challenges before February this year. The COVID-19 epidemic has brought attention to the weakness of international supply networks and fuelled calls for increased European self-sufficiency in key goods and services.

Moreover, the war and the pandemic come at a time when the EU faces the challenges of green and digital transformation.

The policy of reorienting the EU economy in reaction to the Russian invasion of Ukraine, as well as of coordinated EU recovery response to the COVID-19 outbreak, should be centred on increasing resilience by design, not by tragedy. COVID-19's unequal distribution across the major European regions quickly sparked geographic worries about the pandemic's socio-economic, environmental, financial, and demographic components. While the national impacts of the COVID-19 crisis are widely recognised, comprehending its regional consequences will require additional time due to delays in reported data. Why was one location affected more severely than another? What explanations exist for geographical differences? Is it possible to draw connections between the territorial traits likely to affect a disease's propagation and those characteristics? These are the research-focused questions for additional study on the geographical effects of the current crisis, or crises.

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