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A capacity approach to territorial resilience: the case of European regions

Paolo Rizzi[1] · **Paola Graziano**[2] · **Antonio Dallara**[2]

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Abstract Regional resilience is a new paradigm to explain the local system ability to cope with a negative event, tolerating the effect produced by the perturbing action. The first objective of the paper is to analyze the complex concept of regional resilience, adopting a systemic and holistic approach. Using a multidimensional methodology, regional resilience is described by outcome and driver variables, with focus on sustainability of local systems, broken down into the three pillars of economy, society and environment, whereby the holistic approach means that each dimension of territorial sustainable development is partly determined by its relations with the other dimensions. The second aim of the paper is then to test the relations between determinants and outcome of regional resilience. This framework is different compared to previous empirical studies, which primarily focus on economic performance in terms of income or employment dynamics. The model is applied to the case of European regions, to get a map of regional resilience in its different dimensions.

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✉ Paolo Rizzi
paolo.rizzi@unicatt.it

Paola Graziano
paola.graziano@unicatt.it

Antonio Dallara
antonio.dallara@unicatt.it

1 Department of Social and Economic Sciences, Università Cattolica del Sacro Cuore, Piacenza, Italy

2 Local Economy Laboratory, Università Cattolica del Sacro Cuore, Piacenza, Italy

1 Introduction

Sustainability of territorial development, as the future capacity of local systems to support human well-being, is closely associated with the concept of resilience. The more the systems are resilient, the less they likely shift into configurations that involve a reduction in the quantity or quality of territorial assets and resources, as effect of stressors of various nature. The inclusion of resilience in any comprehensive measure of sustainability is necessary to take into account risks that significant losses in well-being may occur (Dasgupta and Mäler 2003).

The scale and impact of shocks and stresses which affect the development of territorial systems increase with the growing of urban areas and the urban population. OECD (2016) classified these stresses into several groups. Industrial structural change (for example relocation or closure of a city's key firms) affects employment in that specific industry and in related ones. Economic crises, such as the financial crisis of 2008 and sovereign debt crises which affect European Union since 2009, have a global impact. The responses of cities depend on characteristics such as the structure of their economy, the proximity to the capital city (OECD 2014) and the internationalization of the local economy (Turcu et al. 2015). Population inflow and outflow influence the employment rate, taxable income, and the need for public services: migration has an important impact on societies and economies, because it lead to social friction, and social integrations constitutes a big challenge for local communities, in particular when they accept asylum seekers. Violence, crime, terrorism may represent critical shocks for a city. In the same way natural disasters (for example earthquakes, floods and hurricanes) have a critical impact not only on environment, but also on the economy and society of territorial system, in particular when they can cause severe disruptions of the energy supply. Leadership change and any discontinuity of policies represent other stressors, which could affect the economic base of a territory and the social structure. Any sort of shock to complex systems such as a territorial system have significant economic, social, environmental and institutional repercussions.

The economic crisis of 2008 constituted the most severe economic downturn in the history of the European Union, which is the investigated area of this study. Not all regions experienced economic decline, and rates of recovery have largely varied. While some places experienced a swift return to pre-crisis levels of employment and economic output, other entered a period of long lasting stagnation. The effects of the economic crisis were relevant across most territories, at a national level Poland and Switzerland were the only states that had not experienced a fall in levels of GDP output. Whereas for employment these two States together with Germany, Luxembourg and Belgium showed the ability to retain pre-crisis employment levels. From 2010 the first signs of recovering regions are visible: Polish regions continued to maintain their stronger GDP performance, and some regions in Germany, Austria, France, Belgium and the Netherlands also managed to contain the declining levels of GDP. In terms of employment, the stronger performance of Germany, Southern France, Belgium, Luxembourg, Malta and of some areas in the UK, Portugal and the Netherlands is evident. GDP decline remains a strong feature of the peripheral economies, but growth has been maintained in regions across a broad group of Poland, Germany, Switzerland, Austria, Slovakia, Netherlands, Belgium and southern France territories (ESPON 2014).

Most of the natural disasters in Europe are due to climatological and hydro-meteorological events. While proactive measures have minimized the loss of human life from disasters, economic losses due to disasters continue to rise in Europe (UNISDR 2016). In a study performed by Munich Re, the effect of 160 natural disasters in Europe in 2014 have been analyzed, highlighting that they caused losses of US$18 billion and an amount of 350 deaths. In particular, it is the case of floods in the Bosnia and Herzegovina, Bulgaria, Croatia and Serbia, the intense storms across France, Belgium and Germany and UK. As a consequence of both development from an anthropic point of view and the increasing impacts of climate change, the trend of economic losses and social costs tends to challenge both sustainability and economic growth.

The economic crisis of 2008, the growing of social inequality, the political and financial instability, the worsening of ecological imbalance and natural disasters represent big challenges for European regions. They lead to a reflection on the need for a definition model of resilience capacity that catch the economic, social and environmental dimensions and effects of the crisis in order to provide adequate responses to the demand for sustainable development policies.

The first aim of this work is to analyze the complex concept of regional resilience, referring to the theoretical background of sustainability. Hence, a systemic and multidimensional approach is adopted and regional resilience is represented as a process and described by outcome and driver variables, connecting them to the three pillars of sustainability (economy, society and environment).

The relationships between outcome and driver variables are complex and characterized by cross-linkages that are poorly investigated in literature. The second aim of this work is to attempt an initial test of the linkages between variables within each dimension and among dimensions of territorial resilience, through the application to the case of European regions.

The work is articulated as follows. The next section focuses on literature review, highlighting the connection between the concepts of competitiveness, sustainability and resilience and the differences between the approach of resilience performance and the one of resilience capacity. The third section introduces the conceptual framework designed by the authors in order to represent territorial resilience from a multidimensional point of view. Outcome and driver variables are defined and connected to the economic, social and environmental dimensions of the phenomenon: GDP per capita, life expectancy and CO_2 emissions for the representation of resilience outcome, 23 variables for the representation resilience capacity, identified through the previous literature review. Unit of analysis, data and multivariate techniques are specified for the construction of resilience composite indicators as well as for the analysis of the relationships among resilience outcomes and drivers: principal component analysis (PCA) and spatial econometric model (SAR). The fourth section presents the results of PCA and the maps of economic, social and environmental resilience of European regions. The last section shows the results of SAR, outlining some differences from OLS regressions, and highlights the effects of economic, social and environmental drivers on GDP pc, life expectancy and CO_2 emissions. In a specific paragraph, an analysis of the economic resilience outcome before and during the global crisis is presented. In the conclusions, paper synthesis and some policy recommendations have been included.

2 Literature review: resilience and sustainability

The notion of resilience has been first elaborated in material sciences: it is in fact the physical property of a material to return to its original shape or position after a deformation that does not exceed its elastic limits. From this meaning, the term was used in different disciplines, but early studies on the topic of resilience are attributable to the research on the environmental phenomena. According to Odum (1985) resilience is the ability of a system to recover when it is affected by a disturbance, with a definition that is very similar to the one used in the field of engineering. The theme of ecological resilience has been studied by Holling (1973) since the early seventies: starting from the analysis of complex systems and adaptive behaviors, he introduced an articulate definition of resilience in the social-ecological systems. According to this perspective resilience is the ability to cope with a negative event, tolerating the effect produced by the perturbing action. A resilient system is able to evolve into multiple states of equilibrium different from the previous one, after the perturbing action, without entering into functional crisis. In this approach, the resilience of a system is its ability to tolerate disturbance, counteracting the increase of entropy produced.[1] The components that feed resilience are those that promote the availability of resources and facilitate the ability to adapt, recover and regenerate (Paton 2001; Resilience Alliance 2007; World Bank 2014).

There is a strong connection between resilience and sustainability. Sustainability captures the aspiration for persistent and equitable well-being in the long run, which is summarized in the dimensions of resilience: the ability to persist and the ability to adapt. Sustainable development has the aim to create and to maintain prosperous social, economic and ecological systems from a co-evolutive point of view. Both sustainability and resilience recognize the need for precautionary action on resource use and on emerging risks aimed at promoting the integrity of well-being into the future.

> Resilience is not about promoting growth or change for its own sake. It is about promoting the ability to absorb shocks and stresses and still maintain the functioning of society and the integrity of the ecological systems…. Most important of all, resilience requires societies to have the capacity to adapt to unforeseen circumstances and risks. These objectives give generic guidance on how to promote sustainability at different scales (Adger 2000).

The theoretical frameworks proposed in regional sciences for the description of resilience (Vale and Campanella 2005; Foster 2007; Pendall et al. 2010; Simmie and Martin 2010; Martin 2012; Graziano and Rizzi 2016; Boschma 2015) offer interesting insights into the analysis of territories capabilities to respond or use the negative event

[1] "The high resilience allows tests of those novel combinations because the system-wide costs of failure are low. The result is the condition needed for creative experimentation" (Holling 2001).

as an opportunity for change and development. One of the charm of resilience notion is its efficacy for understanding, managing and governing complex linked systems of people and nature (Folke et al. 2004). It is a goal that should be promoted, not for ecosystems or for social institutions per se, but for social and ecological system interactions. Resilience thinking promotes the understanding of the co-evolution of socio-economic and ecological systems, which describe territorial development from a multidimensional point of view (Graziano 2014). Resilience facilitates the analysis of the dynamics of social and ecological systems and the definition how those evolutionary cycles enable urban systems to reorganize themselves (Eraydin and Tasan-Kok 2013). Resilience is the ability of maintaining information that organize the territorial system and of introducing variations that can constitute important innovations, in an evolutionary perspective (Boschma 2004; Sotarauta 2005; Martin and Sunley 2007). The applications of these concepts in economic literature (Briguglio et al. 2009; Naudé et al. 2009; Chapple and Lester 2007; Foster 2007; Sotarauta 2005; Liou and Ding 2004), social sciences (Zimmerman and Arunkumar 1994; Cutter and Finch 2007) and ecological and socio-ecological studies (Carpenter et al. 2001; Walker et al. 2004; Folke 2006) have contributed to enrich the notion of resilience with different interpretations.

In regional science the approaches to regional resilience can be summarized into two research lines. The first one identifies resilience as a performance measure (Bailey and Turok 2016; Martin 2012, 2016; Martin and Sunley 2015), the second one identifies resilience as a capacity measure (Cutter and Finch 2007; Foster 2007; Graziano 2014; Graziano and Rizzi 2016; Walker et al. 2004; World Bank 2014).

The first approach is often used to represent the economic dimensions of the phenomenon, analyzing the dynamics of local systems in terms of employment or value added during and after cyclical crises. It is an hazard-specific approach, based on the conceptualization of resilience as a result of a path, which involves the identification of the phases of regional economic recession (in particular the shock and the phase of recovery). According to this approach indicators are calculated to represent resistance during the crisis and recovery after recession. These measures compare the change in regional employment or value added with the national average change, during and after the shock. In this approach the focus of the analysis is on resilience as a performance measure and on its determinants.[2]

The second approach of holistic nature focuses on sustainable development from anthropic and ecological points of view identifying resilience as a complex input, a multidimensional ability which determines the development of territory. It focuses on the capacity to improve autopoietic mechanisms of territorial systems, considering resilience as driver factor. The territory is an open system, characterized by interconnected components and feedbacks that cause nonlinear processes. When the probability of specific shocks is unknown, a holistic approach is useful to provide an initial informative framework of all systemic features and resources that could determine fragility or could influence the adaptation capacity (Walker et al. 2004). This

[2] Regional Studies recently dedicated a themed issue right at the “resilience revisited” (Bailey and Turok 2016), where different authors analyze the resilience processes following this approach in different English, Turkish, Canadian, Australian and European regions.

approach avoids underestimation of unexpected aspects, focusing on factors observed on long periods of time, rather than on resources needed to tackle a specific critical event (Paton 2001). An holistic approach complies with the need for preventive strategies of risk management which needs to combine the capacity to prepare for risk with the ability to cope afterward: preparation should include a combination of actions such as gaining knowledge, acquiring protection and obtaining insurance.[3] The growing interest in this approach to the study of resilience highlights the transition from a culture of emergency and reconstruction, following the occurrence of a specific traumatic event, toward a preventive approach to the problem of risk. It constitutes an attempt to meet the expectations of a territorial planning that has to face the problems arising from the uncertainty of the local systems (Federal Emergency Management Agency 1998; United Nations Commission on Sustainable Development 2001; World Bank 2014).

Table 1 summarizes the elements of description of territorial resilience drivers, emerging from the analysis of theoretical and empirical literature on economic, social and environmental resilience. The characteristics of a resilient system are: availability of resources, low vulnerability and strategic adaptation capacity (Resilience Alliance 2007). Resources availability comes from the endowment of natural, human and economic capital and necessary assets for responding to, withstanding and recovering from adverse situations (Foster 2007; World Bank 2014). Vulnerability is connected to structural homogeneity of the system (Gunderson et al. 1995; Young et al. 2006), and it determines the propensity for damage (Adger 2000). The adaptation capacity refers to adjustments in ecological, social or economic systems in response to present or expected external stimuli, i.e., policies or strategies to moderate vulnerabilities, respond to shocks or reinforce strengths and opportunities (Boschma 2004; Sotarauta 2005).

This specific themes are connected to the three dimensions of sustainability and then to the semantic pillars “resource availability”, “vulnerability” and “strategic adaptation” according to the analyzed literature.

3 A multidimensional approach to regional resilience

The present work focuses on resilience capacity and on the relationships between this ability and territorial well-being, broken down into the three dimensions of sustainability. A vision of territorial well-being as the ability of a given territory to ensure its inhabitants a proper sustainable development in economic, social and environmental terms, is adopted. This is a refocusing of outcome variables that more directly measure standard of living well-being and quality of life: the Gross domestic product per capita in purchasing power parity, as synthetic variable of economic well-being (Huggins and Thompson 2012; Kitson et al. 2004); the life expectancy as indicator of social well-being (Aiginger et al. 2013; Dallara and Rizzi 2012); the CO_2 emissions, as neg-

[3] The World Bank developed a composite indicator of people’s preparation for risk at country level which comprises measures of assets across four components of socio-economic systems: human capital, physical and financial assets, social support, State support (World Bank 2014).

Table 1 The drivers of regional resilience: pillars, themes and basic literature sources

Pillar	Theme	Source
Economic dimension		
Resources availability (+)	Size of local economy	Briguglio et al. (2009), Liou and Ding (2004)
	Accessibility to credit	Naudé et al. (2009)
	Human capital	Sotarauta (2005)
	Territorial capital	Camagni and Capello (2013)
Vulnerability (−)	Openness of the economy	Naudé et al. (2009)
	Dependence on imports and export	Briguglio et al. (2009)
	Production specialization	Boschma (2004)
	Enterprises state of difficulty	World Bank (2014)
Strategic adaptation (+)	Creativity and Innovation	Florida (2002), Sotarauta (2005)
	Collective learning	Morgan (2007), Boschma (2004)
	Strategic Planning	Vazquez-Barquero (2002)
Social dimension		
Resources Availability (+)	Health and Social Infrastructures	Cutter and Finch (2007)
	Social capital	Putnam et al. (1993); Malecki (2012)
	Community Culture	Zimmerman and Arunkumar (1994), Walker et al. (2004)
Vulnerability (−)	Demographic dependency	Cutter and Finch (2007)
	Unemployment	Briguglio et al. (2009)
	Inequality, poverty	World Bank (2014)
	Crime	Blaikie et al. (2004), Naudé et al. (2009)
Strategic adaptation (+)	Collective knowledge, skills coping	Camagni and Capello (2013)
	Welfare policies	Blaikie et al. (2004), Naudé et al. (2009)
	Social Innovation	Baker and Mehmooda (2015)
Environmental dimension		
Resources Availability (+)	Biodiversity	Costanza et al. (2007)
	Wood Land and Green Areas	Tyrvainen et al. (2007)
	Multifunctional agriculture	IPCC Intergovernmental Panel on Climate Change (2001)
Vulnerability (−)	Climate change and natural hazards	World Bank (2014)
	Ecosystem degradation	IPCC Intergovernmental Panel on Climate Change (2001)
	Built-up area and Landscape fragmentation	Tian et al. (2014)

Table 1 continued

Pillar	Theme	Source
	Anthropic pressure	World Bank (2014)
	Air, Soil, Water Pollution	IPCC Intergovernmental Panel on Climate Change (2001)
Strategic adaptation (+)	Sustainable Production and Consumption	Kaly et al. (2004)
	Protected areas	Graziano and Rizzi (2016)
	Renewable Energ	World Bank (2014)
	Separate Waste collection	Dallara and Rizzi (2012)

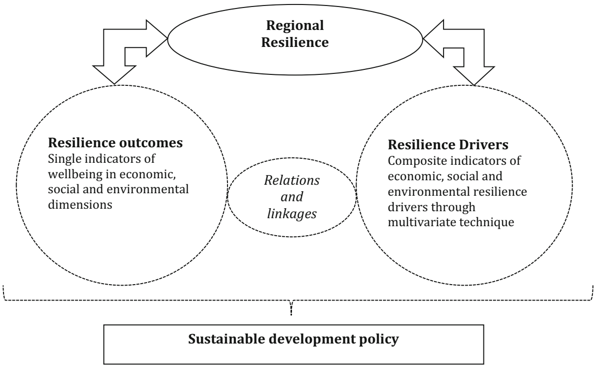

Fig. 1 The regional resilience approach: research design

ative indicator of environmental sustainability (Rizzi et al. 2015; UNDP 2014). These measures will be considered and analyzed separately, in order to better understand the specific relationships between drivers and single outcome variables in the three spheres of sustainability (Table 9 in "Appendix"). Figure 1 shows the research design which highlights outcomes and the drivers of regional resilience, which is represented as a process.

The drivers of resilience are the combination of multiple tangible and intangible elements that are fundamental for maintaining of territorial self-renewal capacity (Graziano and Rizzi 2016). A group of variables has been identified according to the analysis of theoretical and empirical studies on the theme of resilience and vulnerability of economic, social and environmental systems (Table 2).

3.1 Data and methodological aspects

The conceptual framework of regional resilience has been applied to the case of European regions, in order to measure the outcome variables and the resilience drivers in their different dimensions and to highlight the linkages among them. The analysis

Table 2 The drivers of regional resilience: variables and basic literature sources

Variables	Theoretical source
Economic resilience drivers	
Gross fixed capital	Briguglio et al. (2009)
Graduates	Lung et al. (2013), Sotarauta (2005), World Bank (2014)
Patent applications to the EPO	Chapple and Lester (2007), Lung et al. (2013), Sotarauta (2005)
Entrepreneurial density	Foster (2012), Rizzi et al. (2015)
R&D expenditures	Chapple and Lester (2007), Lung et al. (2013), Sotarauta (2005), World Bank (2014)
Employment in S&T sectors	Chapple and Lester (2007), Lung et al. (2013), Sotarauta (2005)
Social economic resilience	
Long-term unemployment	Dow and Juster (1985), Naudé et al. (2009)
Gini Index	Lung et al. (2013), Glatron and Beck (2008), Foster (2012)
Dependency ratio	Cutter and Finch (2007), Jakobsen (2013)
Health infrastructure	Lung et al. (2013), Blackburn and Cassidy (2012), Cutter and Finch (2007)
Infant deaths	Tran et al. (2010)
Circulatory System death rate	Cutter and Finch (2007), Glatron and Beck (2008)
Accidents death rate	Glatron and Beck (2008), Rizzi et al. (2015)
Neet	Rajib (2009)
Lifelong learning	Rajib (2009)
Environmental Economic Resilience	
Biodiversity	Schneiderbauer et al. (2013), Costanza et al. (2007)
Railway density	Rajib (2009), Blackburn and Cassidy (2012), Foster (2012)
Public transport	Blackburn and Cassidy (2012), Foster (2012)
Wood Land	Tran et al. (2010)
Waste collection	Blackburn and Cassidy (2012), Rizzi et al. (2015)
Urbanized areas	Tran et al. (2010), IPCC Intergovernmental Panel on Climate Change (2001)
Motorization rate	Rizzi et al. (2015), IPCC Intergovernmental Panel on Climate Change (2001)
Demographic balance	Tran et al. (2010)

focuses on 248 European regions[4] at NUTS-2 level, observed over the period 2000–2013. EUROSTAT and OECD have been the sources for the collection of 26 variables, used as temporal average: GDP per capita, life expectancy and CO_2 emissions for the representation of resilience outcome, 23 variables for the representation resilience capacity, in the economic, social and environmental dimensions (Table 2).

[4] These regions belongs to 21 European countries, that do not include Bulgarian, Cypriot, Croatian, Lithuanian, Latvian, Maltese, Norwegian, Rumanian regions and the French islands, for the presence of too many missing values.

In order to overcome the difficulties of reading the local systems characteristics through a system of individual indicators and to deal with collinearity problems which could affect the econometric analysis, a method of statistical aggregation of variables has been adopted (Annoni and Kozovska 2010; Dallara and Rizzi 2012; Graziano 2014).

Starting from the initial dataset collected, a group of variables has been selected, according to the result of structure analysis, based on asymmetry and kurtosis checking. When appropriate, the elementary variables have been transformed and then standardized.

Coefficients of Pearson correlation were considered for each pair of variables in order to exclude redundant or too little correlated variables, analyzing the corresponding correlation matrix. Among the couples of variables which displayed correlation coefficients greater than 0.8 or less than 0.3 as absolute value, one of them has been eliminated. This type of approach for the selection of the individual variables and for the construction of the aggregated measures has been adopted to avoid the duplication of information as well as to ensure the possibility to get composite indicators at the same time (Dallara 2008; Jolliffe 2002).

For measuring the resilience drivers, the principal component analysis (PCA) has been applied to the selected variables. The composite indicators which represent resilience drivers are the first component that explains more than 50 percent of the total variance. The loading factors resulting from principal components analysis are the measure of correlation that links the elementary variables to the composite indicator. Through the loading factors it is possible to identify elementary variables that could better describe the phenomenon investigated. The eigenvector associated to the first eigenvalue represents the row vector of the coefficients, which multiply the original variables in the linear combination that generates the new variable, that is the composite indicator.

For the analysis of the relationships among resilience outcomes and drivers, two instruments have been used: scatter plots and econometric models. The econometric models use as regressors both the elementary variables and the three composite indicators obtained by the principal component analysis. The elementary variables are standardized, and they maintain their natural orientation, as well as the three composite indicators are oriented in order to express positive meaning. The aim is to highlight whether and to what extent the elements that describe the resilience drivers act on the outcome variables.

For each dimension of resilience, an OLS regression is first of all proposed using composite indicators as regressors. Skewness–Kurtosis and Shapiro–Wilk tests for normality of residual distribution are reported as well as Breusch–Pagan test for Heteroscedasticity. The choice of use composite indicators depends on the need for deal with collinearity problem (Chatterjee and Hadi 2006). In order to validate this choice, an OLS regression using elementary variables is also proposed, reporting the value of variance inflation factors for collinearity checking.

It is necessary to point out that all the used variables are cross-sectional among the European regions and they are characterized by high spatial autocorrelation (significant Moran's I). The distribution of individual observations (each single region) does not exhibit a constant variance (LeSage 1999). Values of a given variable observed at one region (ith observation) depend on values of neighboring observations at nearby regions, indicating spatial dependence (LeSage and Pace 2009). Spatial interactions, diffusion effects, hierarchies of place, spatial spillovers are causes of spatial dependence among the observations. Moreover, cross-sectional variables present usually a second problem: the spatial heterogeneity in the relationships among variables, which violates the assumption of the classic linear econometric model. In spatial contexts, every region in space holds a different relationship among given variables. In order to take into account these two typical problems of spatial cross-sectional data, the spatial autoregressive model (SAR) introduced in the literature by Whittle and systematized by Cliff and Ord (1973, 1981) is implemented.[5] For each regressions spatial lag and spatial error are reported, using maximum likelihood estimators (ML) and generalized two-stage least square estimators (GL2SLS) as parameters and both elementary variables and composite indicators as regressors.

4 Measuring resilience drivers in European regions

For measuring the resilience drivers, the principal component analysis (PCA) has been applied to the variables that have been selected, according to the result of structure analysis, based on asymmetry and kurtosis checking. In particular, 13 variables define resilience drivers for 248 European regions: 4 variables describing the economic sphere, 5 the social and 4 the environmental dimensions.

Economic resilience drivers can be attributed to physical and human capital, innovation and entrepreneurship. Gross fixed capital per employee is a proxy of resources availability for the economic dimension (Briguglio et al. 2009) the proportion of graduates on population represent the dimension education attainment, as an indicator of resources availability in terms of human capital (Lung et al. 2013; World Bank 2014) research and development expenditure, employees in science-technology sector describe the local innovation system, as fundamental drivers of territorial resilience (Chapple and Lester 2007; Sotarauta 2005).

Social resilience drivers are related basically to social vulnerability. The indicator of death rate for circulatory disease is a proxy of health state (Cutter and Finch 2007; Glatron and Beck 2008), whereas disease for accidents, long-term unemployment rate and the proportion of Neet on population describe the dimension of social hardship

[5] The Cliff and Ord model is described by two equations: $Y = \lambda WY + X\beta + u$ and $u = \rho Wu + \varepsilon$, where ε is assumed to be independent and identically distributed or independent but heteroscedastically distributed, and the heteroscedasticity is of unknown form. In the right member of the first equation among the regressors, a variable of spatial lag is inserted. It is defined pre-multiplying the variable to regress (Y) with the spatial-weighting matrix (W). This endogenous variable (WY) is the weighted average of the dependent variable values observed in other statistical units. By means of the second equation, the model takes into account also that the error terms (u) are generated by a spatial autoregressive process. These two equations estimate simultaneously the values of each statistical unit. Consequently, the values of the dependent variable are not independent from each other. The W matrix is constructed as a matrix of contiguity, considering the geographical proximity of the European regions, and weighing the proximity with the geographical coordinates of the centroid of each region. The parameter λ measures the intensity of spatial interactions and spillovers effects. The parameter measures the spatial autocorrelation of the error term. The parameter β takes into account that in the dependent variables the values of each region are determined simultaneously from each other (Drukker et al. 2013).

which affects negatively the ability of social systems to cope with a negative event (Glatron and Beck 2008; Rizzi et al. 2015). Lifelong learning is a proxy of the self-renewal capacity of local social system (Rajib 2009).

Environmental resilience drivers are connected to the theme of eco-systemic qualities and pressures. Biodiversity is an indicator of heterogeneity of ecological structure, which intensely impacts on territorial resilience. In this work, this measure is referred to land cover (Schneiderbauer et al. 2013; Costanza et al. 2007). Wood land represent the endowment of natural capital, which increases the availability of necessary resources for territorial capability to regenerate. Artificial infrastructures and population growth rate are proxies of anthropic negative forces on nature which negatively affect the resilience capacity of local environmental system.

Table 2 reproduces the obtained results of PCA for the three dimensions, communalities, loading factors, coefficient scores, explained variance and Kmo tests. Table 9 in “Appendix” reproduces the description, the units of measurement and the sources of the final set of 13 variables.

The first component for economic resilience drivers (64% of total variance) is positively correlated with all single variables. For the social resilience drivers the first component that explains 53% of total variance highlights positive correlations with the five vulnerability variables and negative with lifelong learning: so the sign of the regional scores should be reversed when used in the following statistical and econometric analysis to obtain a composite indicator with positive meaning of resilience capacity. Finally the first component of environmental drivers (41% of total variance) displays positive correlation with biodiversity and woodland and negative with urbanized areas and demographic balance as pressure indicators, giving the expected logic meaning to the environmental regional scores (Table 3).

Economic resilience drivers favor the metropolitan regions of the great European capitals and industrialized areas. This is the case of the top 10 capital regions of Hovedstaden (1st place in the ranking), Helsinki-Uusimaa (2nd), Stockholm (3th), Inner London (4th), Île de France (7th), Région de Bruxelles-Capitale (8th), Luxembourg (10th), followed by and Wien (13th) and Praha (14th), which highlight strong economies of urbanization leading to positive demographic flows and to attraction of investments and high-skilled human capital (Fig. 2). In the group of the most resilient regions several areas of Germany, Belgium and UK emerge: some with a strong presence of high tech discricts (Oberbayern, Berkshire, Buckinghamshire and Oxfordshire, respectively, at the 6th and the 18th place in the ranking), with a remarkable trade vocation (Hamburg and Antwerpen, at the 9th and 23th positions) and with the highest density of scientific, academic and research organizations (Walloon Brabant and Stuttgard, respectively, at the 5th, and 17th places), because of their high propensity to private and public investment in innovation and a widespread quality of human capital.

In contrast Swietokrzyskie, Kujawsko-Pomorskie, Lubuskie and Opolskie in Poland, Ionia Nisia and Notio Aigaio in Grece, Východné Slovensko and Západné Slovensko in Slovakia, and Észak-Magyarország in Hungaria highlight the lowest levels of economic resilience drivers in Europe. These regions are located in the European areas characterized by the small presence of economic infrastructures, they reach the lowest level of Gross Fixed Capital and are characterized by poor private and pub-

Table 3 The PCA results for the resilience drivers (248 European regions Nuts 2)

	Communalities (2)	Loading factors (3)	Coefficient scores (4)	Variance explained (%)	KMO (*p* value)
Economic resilience drivers (high) (1)				64	0.717 (0.000)
Gross fixed capital per empl.	0.493	0.702	0.275		
Employment in S&T sectors	0.677	0.823	0.323		
Graduates on population	0.554	0.744	0.292		
R&D expenditures	0.827	0.909	0.356		
Social resilience drivers (low) (1)				53	0.604 (0.000)
Long-term unemployment rate	0.669	0.818	0.306		
Death rate for circul.disease	0.221	0.470	0.176		
Death rate for accidents	0.540	0.735	0.275		
Neet rates	0.450	0.671	0.251		
Lifelong learning rates	0.796	− 0.892	− 0.333		
Environmental resilience drivers (high) (1)				41	0.633 (0.000)
Biodiversity index	0.305	0.552	0.333		
Woodland (forest cover)	0.584	0.764	0.461		
Urbanized areas	0.509	− 0.713	− 0.430		
Demographic balance	0.261	− 0.511	− 0.308		

(1) In brackets the meaning (logic sign) assigned to the composite indicator, also derivable from the sign of the coefficient score of elementary variables that comprise it
(2) Final commonality indicates the variance contribution of each elementary variable that is captured by the composite indicator defined by the PCA (set equal to one the variance of each elementary variable)
(3) Loading factor measures the correlation between each elementary variable and the first main component
(4) Coefficient scores are the coefficients with which to multiply each standardized elementary variable to obtain the first principal component

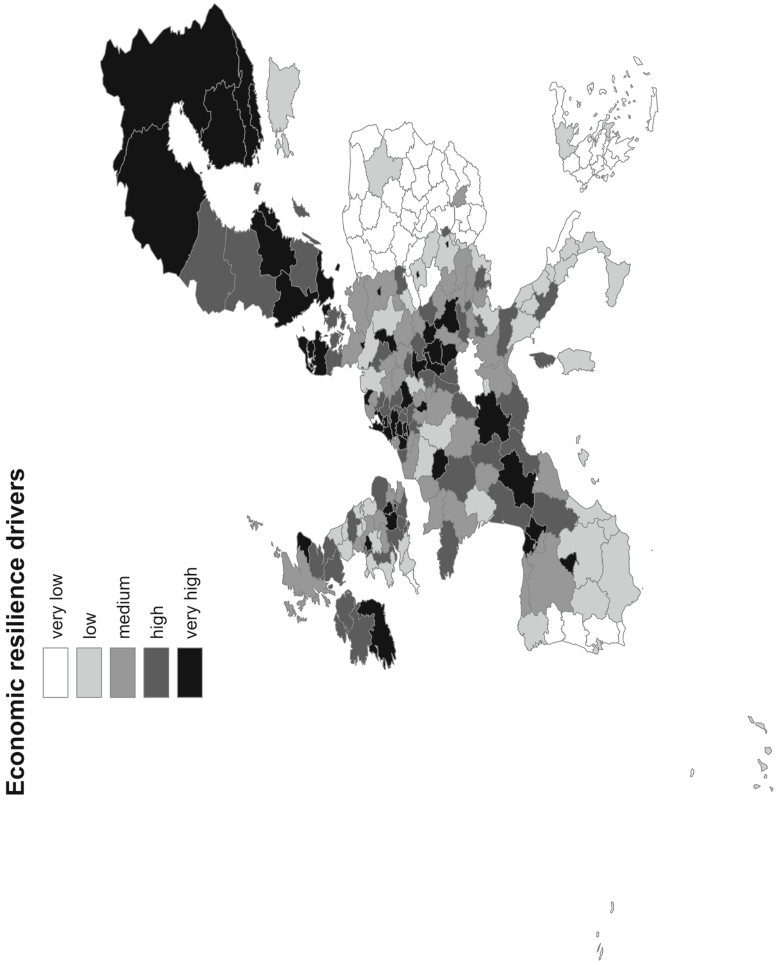

Fig. 2 The map of economic resilience drivers in European regions

lic investments in innovation. In addition to the known dichotomy between regions of the Blue Banana and Northern Europe on one hand and the Mediterranean (South of Spain, Italy and Greece) and Eastern Europe (Hungary and Poland) on the other hand, it is possible to point out the good performance of some wealthy areas but peripherals such as Midi-Pyrénées in France and País Vasco in Spain.

These data are confirmed by several regional resilience studies in terms of employment or Gdp pc in countries such as Italy (Di Caro 2015; Lagravinese 2015), Spain (Cuadrado-Roura and Maroto 2016), Hungary (Benke et al. 2016), Slovakia (Hudec et al. 2016), Poland (Masik 2016) and in general from comparative studies at European level (ESPON 2014; Sensier et al. 2016; Crescenzi et al. 2016; Giannakis and Bruggeman 2017). In the case of Greek regions there are different results regarding regional levels of resilience: Giannakis and Bruggeman (2015) found that the coastal and rural regions of Greece (Ionia Nisia, Notio Aigaio and Voreio Aigaio) were more resilient to the recent economic crisis than the continental urban regions for the sectoral composition of these economies and the positive role of agriculture, agro-industry and tourism.

Social resilience drivers are linked with the economic ones, with the best results of Scandinavian regions bathed by the North Sea and the Norwegian Sea (Fig. 3). In the top 10 group, the high level of social resilience drivers of Midtjylland, Syddanmark in Denmark, Hampshire and Isle of Wight in the English Channel emerge. The map confirms the excellent performance of capital regions of Stockholm (1st place), Helsinki (4th), Outer and Inner London (17th and 22th) and the good result of Madrid (66th), Île de France (69th) and Praha (72th), because of low level of long-term unemployment and death rate for accident as well as high level of self-renewal capacity, represented by population involved in lifelong learning programs.

It is also possible to observe the excellent positioning of some Duch areas such as Utrecht (3th) in Randstad's polycentric urban region due to a low level of social hardship highlighted by the lowest rate of Neet. The performance of some Southern English regions as Surrey, East and West Sussex (10th), Berkshire, Buckinghamshire and Oxfordshire (11th), Gloucestershire, Wiltshire and Bristol (13th) is explained by the high rate of participation in lifelong learning programs reflected in a very low rate of long-term unemployment. It is possible to notice some regions in the group of ones that record a good level of social resilience drivers which are characterized also by a low level of social hardship, such as in the Austro-German area: Vorarlberg, Tirol, Salzburg, Freiburg, Oberbayern, Stuttgart, Tübingen and, in particular, Hamburg with the lowest death rate for accident in Europe. The performance of Alsace and Rhône–Alpes French regions is noticeable, as well as some peripheral ones such as Bretagne and Pays de la Loire due to the best performance in health dimension represented by low death rate for circulatory disease. This is also the case of the Spanish Comunidad Foral de Navarra and País Vasco, which demonstrate how even poorly urbanized areas are able to reach a social balance and quality of life more than acceptable.

On the contrary, it is possible to notice the worst performance of some Greek regions such as Sterea Ellada, Peloponnisos, Anatoliki Makedonia, Ipeiros, Dytiki Makedonia, and Thessalia, but also of Sicily in Italy as marginal area characterized by high level of all components of social hardship and low of self-renewal abilities. In the bottom 10 the Slovakian regions of Západné Slovensko, Stredné Slovensko and Východné

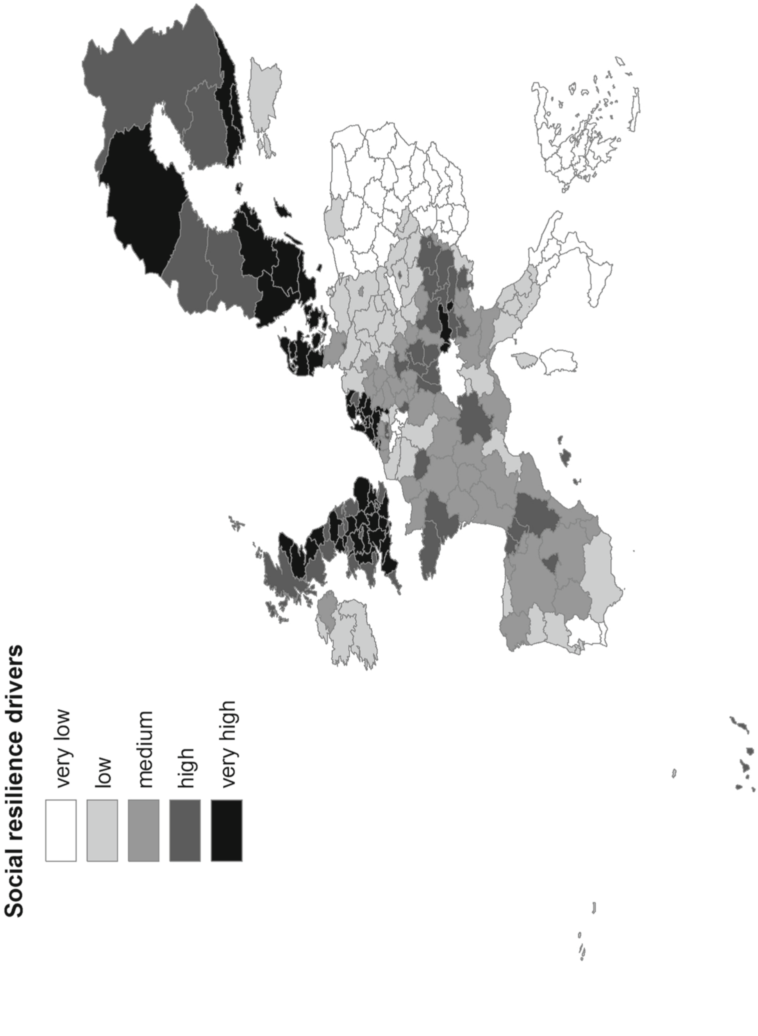

Fig. 3 The map of social resilience drivers in European regions

Slovensko record a very low level of social resilience drivers due to the highest death rate and social hardship.

Environmental resilience drivers reverse the picture emerged in terms of territorial economic and social factors: the richest regions of the UK and the Netherlands are in fact the most penalized where the northern European areas of Sweden (Norra Mellansverige, Småland med öarna, Mellersta Norrland and Övre Norrland) and Finland (Pohjois-ja Itä-Suomi, Etelä-Suomi), some Austrian (Steiermark and Kärnten), and German regions (Oberfranken and Gießen) are awarded thanks to the large extensions of wood land and the low urbanization (Fig. 4). But in the top of the ranking, also some poor regions of Portugal (Alentejo, Centro, Açores), Italy (Calabria, Molise, Basilicata) and Slovenija (Vzhodna and Zahodna Slovenija) show positive ecological balances thanks to lower environmental pressures because of minor industrial and infrastructural sites; the same evidence in some East Europe regions such as Stredné Slovensko in Slovakia and Moravskoslezsko in Czech Republic.

On the contrary, UK regions as Inner and Outer London, West Midlands, Merseyside, Manchester and West Yorkshire, German regions as Hamburg and Bremen, or Dutch and Belgian regions such as Utrecht, Flevoland and Bruxelles, show low level of environmental resilience drivers for their diseconomies of urbanization due to production and transport congestions.

5 The relations between drivers and outcome of regional resilience

In this section, the relationships between the composite indicators defined for measuring the drivers of regional resilience and the single outcome variables are presented. It resorts to scatter plots that display the relative positioning of each European region and the relationships between the variables, and correlation matrix.

Among the economic outcome and the economic resilience drivers (Fig. 5), a marked positive relationship is observed (Fig. 5): European regions that are characterized by the best levels of outcome variable (GDP per capita) seem to be so driven by higher economic resilience capacity, as measured by levels of innovation and research, technology and capital investment.

It is the cases of Inner London, Luxembourg, Bruxelles Capitale, Hamburg, Helsinki-Uusimaa and Hovedstaden, regions with high levels of virtuosity and good performance of economic resilience drivers. Some regions, such as Ionia Nisia and Notio Aigaio (Greece), Lubuskie (Poland), Észak-Magyarország and Dél-Dunántúl (Hungary), are penalized in terms of economic outcome and unsatisfactory results also in terms of economic drivers.

The composite indicator of social resilience drivers affects the social performance of regions in terms of life expectancy (Fig. 6). The correlation is still positive, albeit to a lesser extent than the economic dimension. The comparison between outcome and determinants rewards some rich areas (Stockholm and Utrecht) but also some Spanish regions (Madrid and Comunidad Foral de Navarra), virtuous regions in terms of life expectancy and good endowment of social resilience drivers as quality of human capital. It is possible to observe some exceptions such as Ipeiros in Greece or Molise and Abruzzo in Italy (high level of outcome, low level of social drivers) and the English

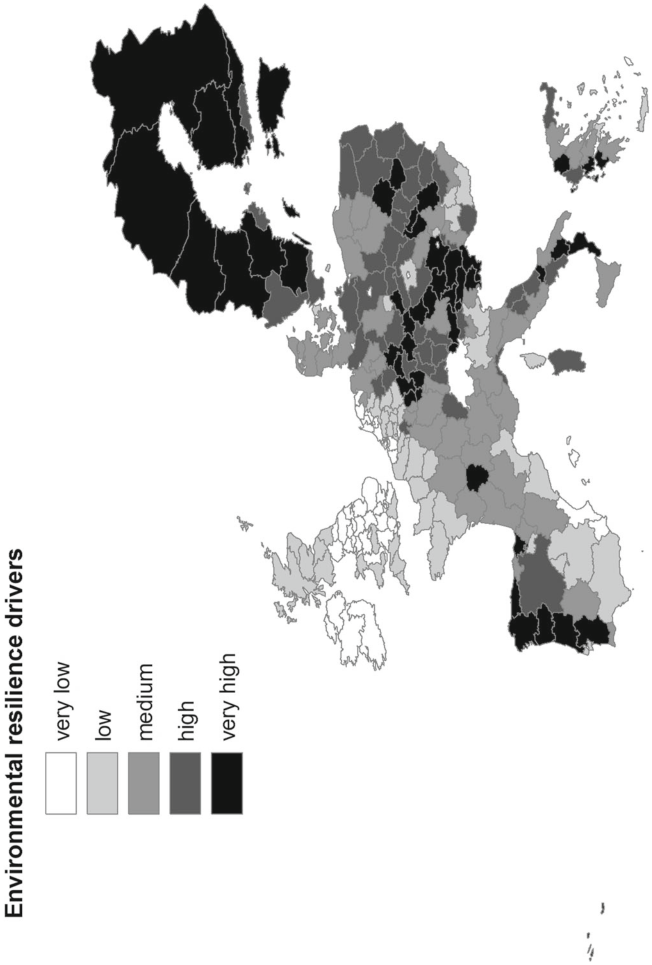

Fig. 4 The map of environmental resilience drivers in European regions

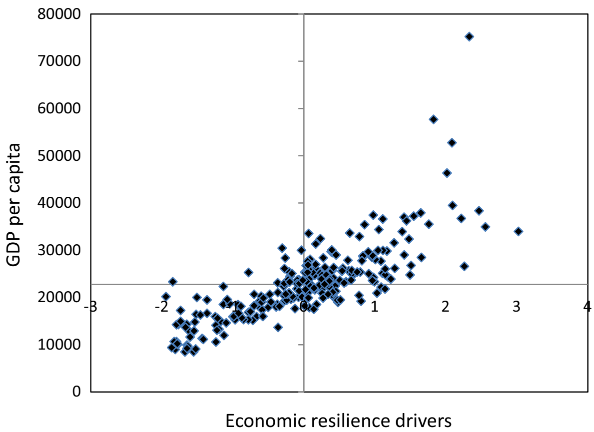

Fig. 5 The relations between drivers and outcome of economic regional resilience

Fig. 6 The relations between drivers and outcome of social regional resilience

regions of Greater Manchester, Eastern and South Western Scotland (penalized in terms of life expectancy despite the excellent social resilience drivers). It can be said that the response capacity of local systems at social level does not seem to be for all regions a good driver for the social welfare dimension.

Environmental resilience drivers instead are negatively correlated with ecological outcome (CO_2 emissions), with the best "twin" performance in Swedish regions of Ovre Norrland, Mellersta Norrland and Norra Mellan Sverige and in Alentejo (lower right quadrant) while the worst "twin" performance in the metropolitan areas of Berlin, London and Bruxelles (left upper quadrant). But it is possible to observe some mixed case of high levels of ecological vulnerability associated with high values of resilience drivers, linked to active policies of land use (German regions of Saarland, Arnsberg and Darmstadt). In these cases, a possible explanation is because resilience drivers develop in response to vulnerabilities but do not solve them. Such considerations lead to more

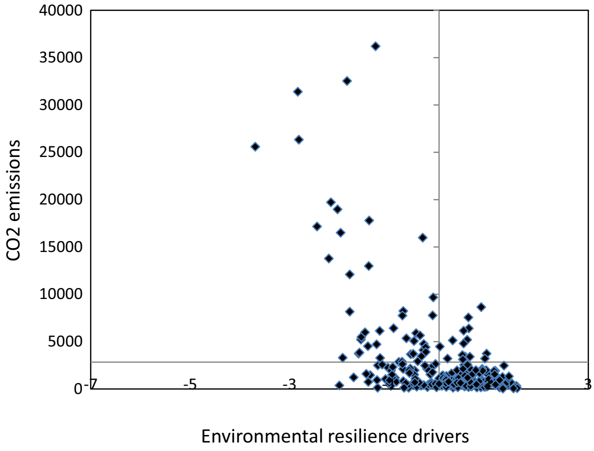

Fig. 7 The relations between drivers and outcome of environmental regional resilience

emphasis on the role of governance and policy measures that could be characterized either as preventive or as palliative (Fig. 7).

In general the correlation matrix between outcome variables and drivers of regional resilience (Table 4) shows different linkages among economic, societal and environmental dimensions, setting the stage for an in-depth analysis of these relations. The study of links in the following section could be helpful to clarify which factors contribute most to explain the resilience in European regions.

The estimated relations between GDP pc and the variables that describe resilience drivers are reproduced in Table 5. When using elementary variables as regressors (first column) in the OLS, residuals do not have a normal distribution and are heteroscedastic. Furthermore, the mean variance inflation factors greater than unity reveal that there is some evidence of collinearity (Chatterjee and Hadi 2006). The correlation matrix of the economic resilience drivers highlights significant bivariate linear relationships, and the same occurs for social resilience and environmental resilience variables.

Because of these correlations and the value of mean VIF, a new OLS is estimated, in which the elementary variables are substituted by the unique principal component with the eigenvalue greater than unity and these first components are inserted in the OLS as regressors. The same approach is applied to the variables of economic, social and environmental resilience drivers (second column). In this case, the GDP pc is positively linked with economic resilience drivers, but negatively with environmental ones, highlighting a clear trade-off between economy and environment. The linkage between GDP pc and social resilience drivers is not significant. In this second OLS, the mean VIF decreases, but residuals are non-normal distributed and heteroscedastic.

In order to deal with spatial cross-sectional data (spatial dependence and spatial heterogeneity), the spatial autoregressive model (SAR) is implemented. The third column of Table 5 presents the results: the GDP pc is regressed with the elementary variables that make up the economic, social and environmental resilience drivers. The parameters are maximum likelihood estimators (ML), they retain the same signs

Table 4 The correlation matrix

	Economic resilience drivers	Social resilience drivers	Environmental resilience drivers	GDP per capita	Life expectancy	CO_2 emissions
Economic resilience drivers	1					
Social resilience Drivers	0.703** (0.000)	1				
Environmental resilience drivers	−0.297** (0.000)	−0.374** (0.000)	1			
GDP per capita	0.796** (0.000)	0.565** (0.000)	−0.405** (0.000)	1		
Life expectancy	0.520** (0.000)	0.464** (0.000)	−0.099 (0.147)	0.483** (0.000)	1	
CO_2 emissions	0.344* (0.000)	0.213** (0.000)	−0.637** (0.000)	0.534** (0.000)	0.012 (0.769)	1

The correlation is significant at: ** the 0.01 level (2-tailed); * the 0.05 level (2-tailed)

Table 5 Economic regional resilience: outcome and drivers (dependent variable: GDP per capita ppp mean 2003–2012)

Independent variables	OLS	OLS	SAR model (ML)	SAR-R model (GL2SLS)	SAR-R model (GL2SLS)
Economic resilience drivers		0.093*** (0.006)			0.093*** (0.010)
R&D expenditures	0.084*** (0.03)		0.093*** (0.03)	0.096*** (0.03)	
Employment in S&T sectors	0.078** (0.04)		0.085* (0.04)	0.087** (0.04)	
Gross fixed capital per employee	0.387*** (0.04)		0.396*** (0.04)	0.399*** (0.05)	
Graduates	0.033 (0.03)		0.026 (0.03)	0.024 (0.03)	
Social resilience drivers		−0.010 (0.006)			−0.005 (0.010)
Long-term unemployment	−0.064** (0.03)		−0.067* (0.03)	−0.069** (0.03)	
Circulatory system death rate	0.081*** (0.03)		0.074** (0.03)	0.069* (0.04)	
Accidents mortality	−0.060* (0.03)		−0.060* (0.03)	−0.061 (0.04)	
NEET	−0.098*** (0.03)		−0.108*** (0.03)	−0.112*** (0.04)	
Lifelong learning	−0.111*** (0.03)		−0.110*** (0.03)	−0.110*** (0.04)	
Environmental resilience drivers		−0.023*** (0.005)			−0.031** (0.014)
Biodiversity	−0.031 (0.02)		−0.033 (0.02)	−0.035 (0.03)	
Woodland	0.018 (0.02)		0.014 (0.02)	0.014 (0.02)	
Artificial infrastructures	0.224*** (0.03)		0.223*** (0.04)	0.222** (0.09)	
Population growth rate	0.089*** (0.03)		0.083*** (0.03)	0.080* (0.04)	
Constant	0.021 (0.05)	0.215*** (0.004)	0.045 (0.05)	0.057 (0.06)	0.219*** (0.008)
no. obs.	248	248	248	248	248
Adjusted R^2	0.782	0.661			
F	69.11	161.80			
Prob (F)	0.0000	0.0000			
Wald χ^2			606.96		
Prob. (χ^2)			0.0000		

Table 5 continued

Independent variables	OLS	OLS	SAR model (ML)	SAR-R model (GL2SLS)	SAR-R model (GL2SLS)
Heteroscedasticity					
Breusch–Pagan test (χ^2)	247.51	125.43			
Prob. (χ^2)	0.0000	0.0000			
Normality of residuals					
Skewness–Kurtosis test: prob. (χ^2)	0.0000	0.0000			
Shapiro–Wilk test (sw)	7.674	6.955			
Prob. (sw)	0.0000	0.0000			
Multicollinearity					
VIF test (mean)	2.69	1.75			
Spatial Lag (λ)—lambda ($p > \|z\|$)			-0.076 ($p = 0.216$)	-0.108 ($p = 0.182$)	
Spatial error (ρ)—rho ($p > \|z\|$)			0.058 ($p = 0.628$)		0.554 ($p = 0.000$)

The quantities in parentheses below the estimates are the standard errors; significance of estimates: *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$

obtained with the previous OLS, and the spatial lag is significant (p-value of λ is less than 0.05) while the spatial error (ρ) is not significant.

In the fourth column of Table 5 generalized two-stage least square (GL2SLS) estimators for the parameters of the spatial autoregressive model with spatial autoregressive disturbances are presented.[6] The parameters retain the same signs of the previous regressions and the spatial lag is significant, indicating spatial autoregressive dependence in GDP pc.

When the GDP pc is regressed with the composite indicators of economic, social and environmental resilience drivers, using heteroscedasticity consistent estimators (GL2SLS), the parameter signs result positive for economic drivers but negative for environmental ones, confirming the presence of trade-off between economic and environmental dimensions, just observed in OLS equations (last column of Table 5). The linkage between GDP pc and social resilience drivers is negative but not significant. The spatial error is significant, indicating spatial autoregressive dependence in error term.

In general, the results confirm findings from other regional resilience studies, in particular the positive role on Gdp pc of gross fixed capital formation, share of employment in science and technology, research and development expenditures (Giannakis and Bruggeman 2017; Crescenzi et al. 2016), with the exception of graduate and lifelong learning effect, and the negative role of unemployment.

The relationships between the life expectancy and the drivers of economic, social and environmental resilience are presented in Table 6. The ordinary least squares present the same problems discussed for the GDP: multicollinearity, non-normality of residuals, heteroscedasticity. The spatial autoregressive models retain the same parameters signs obtained with the OLS except for employment in S&T sectors, woodland and population growth rate and the spatial and error lag are significant. Then the SAR model which implements maximum likelihood estimators to the synthetic indicators shows that the life expectancy is positively related with economic and social resilience drivers while the linkage with environmental resilience is not significant significant. So the social outcome, represented by life expectancy, seems to largely depend on the economic and social dimensions.

Table 7 presents the relationships between the ecological territorial outcome (CO_2 emissions) and the economic, social and environmental drivers of resilience. Considering the composite indicators, the inverse relation between CO_2 emission and economic resilience drivers emerges, as well as the direct one with the social and environmental dimensions. In order to overcome the problems of non-normality and multicollinearity, the spatial autoregressive models are used, displaying the same parameters signs obtained with the OLS. The last column of the table presents the spatial autoregressive model which implements generalized two-stage least square estimators to the synthetic indicators.

[6] This estimator is consistent and robust when the error term is heteroscedastically distributed.

Table 6 Social regional resilience: outcome and drivers (dependent variable: life expectancy mean 2003–2012)

Independent variables	OLS	OLS	SAR model (ML)	SAR-R model (GL2SLS)	SAR model (ML)
Economic resilience drivers		0.083*** (0.016)			0.030** (0.012)
R&D expenditures	0.240*** (0.07)		0.059 (0.05)	0.105** (0.04)	
Employment in S&T sectors	−0.132 (0.08)		0.229*** (0.08)	0.145 (0.11)	
Gross fixed capital per employee	0.401*** (0.08)		0.162** (0.06)	0.247*** (0.08)	
Graduates	−0.224*** (0.06)		−0.148** (0.06)	−0.162** (0.08)	
Social resilience drivers		0.048** (0.017)			0.058*** (0.018)
Long-term unemployment	−0.053 (0.06)		−0.145*** (0.05)	−0.137* (0.08)	
Circulatory System death rate	−0.634*** (0.06)		−0.769*** (0.08)	−0.683*** (0.09)	
Accidents mortality	−0.217*** (0.07)		−0.026 (0.054)	−0.077 (0.06)	
NEET	−0.017 (0.07)		−0.087 (0.07)	−0.016 (0.07)	
Lifelong learning	−0.060 (0.07)		−0.276*** (0.08)	−0.161 (0.11)	
Environmental resilience drivers		0.023* (0.012)			0.002 (0.011)
Biodiversity	0.067 (0.05)		0.041 (0.04)	0.063 (0.05)	
Woodland	0.069* (0.04)		−0.067 (0.04)	−0.022 (0.05)	
Artificial infrastructures	−0.162** (0.07)		−0.147** (0.06)	−0.186*** (0.07)	
Population growth rate	−0.020 (0.07)		−0.015 (0.05)	0.001 (0.06)	
Constant	1.093*** (0.11)	0.683*** (0.011)	1.356*** (0.11)	1.146*** (0.13)	0.729*** (0.027)
No. obs.	248	248	248	248	248
Adjusted R^2	0.689	0.286			
F	43.06	33.91			
Prob (F)	0.0000	0.0000			
Wald χ^2			248.750		41.705
Prob. (χ^2)			0.0000		0.0000

Table 6 continued

Independent variables	OLS	OLS	SAR model (ML)	SAR-R model (GL2SLS)	SAR model (ML)
Heteroscedasticity					
Breusch–Pagan test (χ^2)	21.62	38.40			
Prob. (χ^2)	0.0000	0.0000			
Normality of residuals					
Skewness–Kurtosis test: prob. (χ^2)	0.0165	0.0417			
Shapiro–Wilk test (sw)	1.442	2.678			
Prob. (sw)	0.0746	0.0037			
Multicollinearity					
VIF test (mean)	2.69	1.75			
Spatial lag—lambda ($p > \|z\|$)			−0.089 ($p = 0.098$)		−0.104 ($p = 0.135$)
Spatial error—rho ($p > \|z\|$)			0.820 ($p = 0.000$)	0.783 ($p = 0.000$)	0.838 ($p = 0.000$)

The quantities in parentheses below the estimates are the standard errors; significance of estimates: *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$

Table 7 Environmental regional resilience: outcome and drivers (dependent variable: CO_2 emissions mean 2003–2012)

Independent variables	OLS	OLS	SAR model (ML)	SAR-R model (GL2SLS)	SAR model (GL2SLS)
Economic resilience drivers		0.034*** (0.007)			0.034*** (0.007)
R&D expenditures	− 0.018 (0.02)		− 0.012 (0.02)	− 0.016 (0.02)	
Employment in S&T sectors	− 0.039 (0.03)		− 0.037 (0.03)	− 0.039 (0.03)	
Gross fixed capital per employee	0.051* (0.03)		0.066** (0.03)	0.066** (0.03)	
Graduates	0.012 (0.02)		0.014 (0.02)	0.017 (0.02)	
Social resilience drivers		− 0.026*** (0.007)			− 0.023** (0.009)
Long-term unemployment	0.013 (0.02)		0.012 (0.02)	0.011 (0.02)	
Circulatory System death rate	0.060*** (0.02)		0.068*** (0.02)	0.066*** (0.02)	
Accidents mortality	− 0.014 (0.02)		− 0.013 (0.02)	− 0.015 (0.02)	
NEET	0.033 (0.02)		0.042* (0.02)	0.040* (0.02)	
Lifelong learning	0.027 (0.02)		0.020 (0.03)	0.016 (0.03)	
Environmental resilience drivers		− 0.064*** (0.005)			− 0.082*** (0.006)
Biodiversity	− 0.018 (0.02)		− 0.013 (0.02)	− 0.012 (0.02)	
Woodland	0.049*** (0.01)		0.052*** (0.02)	0.057*** (0.02)	
Artificial infrastructures	0.690*** (0.03)		0.648*** (0.03)	0.640*** (0.03)	
Population growth rate	0.025 (0.02)		0.026 (0.02)	0.026 (0.02)	
Constant	− 0.129*** (0.04)	0.047*** (0.005)	− 0.153*** (0.04)	− 0.151*** (0.04)	0.035*** (0.011)
no. obs.	248	248	248	248	248
Adjusted R^2	0.837	0.458			
F	98.56	70.57			
Prob. (F)	0.0000	0.0000			
Wald χ^2			967.046		
Prob. (χ^2)			0.0000		

Table 7 continued

Independent variables	OLS	OLS	SAR model (ML)	SAR-R model (GL2SLS)	SAR model (GL2SLS)
Heteroscedasticity					
Breusch–Pagan test (χ^2)	1201.56	568.09			
Prob. (χ^2)	0.0000	0.0000			
Normality of residuals					
Skewness–Kurtosis test: prob. (χ^2)	0.0000	0.0000			
Shapiro–Wilk test (sw)	8.674	8.254			
Prob. (sw)	0.0000	0.0000			
Multicollinearity					
VIF test (mean)	2.69	1.75			
Spatial lag—lambda ($p > \|z\|$)			0.246 ($p = 0.000$)	0.302 ($p = 0.000$)	0.692 ($p = 0.001$)
Spatial error—rho ($p > \|z\|$)			0.139 ($p = 0.214$)	0.135 ($p = 0.190$)	0.601 ($p = 0.000$)

The quantities in parentheses below the estimates are the standard errors; significance of estimates: *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$

5.1 The economic resilience outcome before and during the global crisis

As in the empirical analysis presented in previous paragraphs, also in this one some relationships between the GDP per capita, interpreted as an economic outcome of resilience, and inputs of economic and social resilience are analyzed.[7] As in some recent papers (Crescenzi et al. 2016; Giannakis and Bruggeman 2017), the entire time period analyzed previously is subdivided in two parts: the pre-crisis period (2005–2007) that immediately preceded the global economic and financial shock and the post-2008 period (2008–2013). In each of these two periods the arithmetic average of GDP pc and of resilience indicators are the values inserted in the relations analyzed. The regression method based on the ordinary least squares (OLS) is the benchmark, and a spatial autoregressive model is also implemented

In both periods the ordinary least squares (Table 8) shows that the GDP pc is positively related with the three inputs of economic resilience: R&D expenditures, gross fixed capital per employee and graduates. The sign of these three parameters is as expected, but the R&D expenditures are not significant in statistical terms.

The GDP pc is negatively related with five input of social resilience: long-term unemployment, circulatory system death rate, transport accidents death rate, Neet, lifelong learning. The coefficient signs are the expected ones, with the exception of life long learning.

These OLS regressions are robust respect with residuals' heteroscedasticity that are not normally distributed. The variance inflation factor (VIF) of each variable is acceptable according the prevalent rule of thumb proposed in empirical literature (Chatterjee and Hadi 2006).

As the cross-sectional observations under investigation are not independent of one another, spatial autoregressive models are applied. In these models, regressors with a statistically non-significant parameter (R&D expenditures, long-term unemployment) and that one with an unexpected sign (lifelong learning) are deleted.

In both periods physical and human capital are the most relevant drivers of resilience: these factors, which express the territorial availability of resources, grow in importance during the period when the crisis has manifested its effects, more than the adaptation capacity drivers, as the increasing magnitude of the coefficients indicates.

6 Conclusions

The paper analyzes the complex concept of regional resilience, adopting an holistic approach which distinguishes the three dimensions of sustainability (economy, society and environment) and outcome-driver variables. This approach is different than most of previous empirical studies, which primarily focus on economic performance in terms of income or employment dynamics during and after crisis cycles. The model is applied to the case of European regions, to get a geographical map of territorial resilience in its different dimensions.

[7] The environmental resilience cannot be taken under consideration because of missing data. This causes the reduction in the number of European regions considered.

Table 8 Economic regional resilience: outcome and drivers (dependent variable: GDP per capita ppp, mean 2005–2007 and 2008–2013)

	2005–2007			2008–2013		
Independent variables (mean 2005–2007 in columns (1), (2), (3) and mean 2008–2013 in (4), (5), (6))	OLS robust (1)	SAR model (ML) (2)	SAR-R model (GL2SLS) (3)	OLS robust (4)	SAR model (ML) (5)	SAR-R model (GL2SLS) (6)
Economic resilience						
R&D expenditures	0.059 (0.064; 1.74)			0.030 (0.078; 1.71)		
Gross fixed capital per employee	0.213* (0.115; 3.22)	0.144* (0.078)	0.191 (0.118)	0.368*** (0.079; 2.13)	0.272*** (0.080)	0.371*** (0.113)
Graduates	0.245** (0.102; 2.53)	0.343*** (0.074)	0.288*** (0.105)	0.181** (0.082; 1.98)	0.549*** (0.081)	0.324** (0.156)
Social resilience						
Long-term unemployment	− 0.027 (0.071; 2.13)			0.102 (0.127; 3.17)		
Circulatory system death rate	− 0.017 (0.062; 2.47)	− 0.121 (0.103)	− 0.038 (0.074)	0.030 (0.072; 2.51)	0.068 (0.089)	0.065 (0.088)
Transport accidents death rate	− 0.313*** (0.055; 2.19)	− 0.252*** (0.058)	− 0.255*** (0.058)	− 0.296*** (0.050; 2.02)	− 0.243*** (0.057)	− 0.285*** (0.062)
Neet	− 0.152** (0.076; 2.07)	0.013 (0.085)	− 0.054 (0.137)	− 0.349*** (0.084; 2.75)	− 0.020 (0.078)	− 0.187 (0.189)
Lifelong learning	− 0.111** (0.048; 2.65)			− 0.086 (0.054; 2.31)		
Constant	0.341*** (0.086)	0.270*** (0.065)	0.243** (0.121)	0.264*** (0.064)	0.126 (0.079)	0.210 (0.205)
No. obs.	150	150	150	184	184	184
R^2	0.7087			0.6421		

Table 8 continued

	2005–2007			2008–2013		
F	72.54			46.77		
Prob. (F)	0.0000			0.0000		
Wald χ^2		156.334			248.933	
Prob. (χ^2)		0.0000			0.0000	
Heteroscedasticity						
Breusch–Pagan test (χ^2)	–					
Prob. (χ^2)	–					
Normality of residuals						
Skewness–Kurtosis test: prob. (χ^2)	0.0000			0.0000		
Shapiro–Wilk test (sw)	5.678			5.623		
Prob. (sw)	0.0000			0.0000		
Multicollinearity						
VIF test (mean)	2.38			2.32		
Spatial lag (λ)—lambda ($p > \|z\|$)					-0.210 ($p = 0.023$)	
Spatial error (ρ)—rho ($p > \|z\|$)		0.512 ($p = 0.000$)	0.398 ($p = 0.003$)		0.730 ($p = 0.000$)	0.590 ($p = 0.000$)

For each OLS regressor, quantities in parentheses below the estimates are, respectively, standard errors and VIF; for SAR models only standard error; significance of estimates: *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$

Applying the principal component analysis, the drivers are synthesized in composite indicators and used for mapping the European regional resilience factors. Then they are used as regressors in both the OLS and the Spatial Autoregressive Model to deal with the problems of spatial lags, multicollinearity and non-normality of residuals.

The descriptive and econometric results show something expected and some new evidence.

The first expected evidence in the descriptive analysis is the well-known map of European economic and social well-being, which results more intensive in the metropolitan regions of the capitals and industrialized areas, penalizing conversely the Mediterranean regions of Spain, Italy and Greece, Portugal and Eastern Europe. But the costs of good economic and social performances are found in poor environmental resilience drivers in the Blue Banana regions, with the exception of Scandinavian area, capable of positive ecological balance.

The second expected result is the positive relation between territorial outcome and regional resilience drivers: so the economic drivers, such as innovation, investment and human capital, help to explain the level of economic well-being measured by gross domestic product per capita; the same for life expectancy, considered as proxy of social well-being, which is related with social resilience drivers such as low mortality rate, low unemployment level or social hardship; finally the drivers of environmental resilience, such as high level of biodiversity and low level of artificial areas, explain good ecological outcome, summarized in low level of emissions.

But the model also analyzes the cross and cumulative relationships among the three spheres of resilience in their outcome and drivers elements, with new emerging evidence through some econometric models. In the economic dimension, the social and environmental drivers of regional resilience are negatively related to economic outcome, highlighting a double trade-off, as if to say that the components of social and ecological welfare are in some cases obstacles or brakes to the wealth measured by income per capita. The same result is obtained in the environmental sphere, where the economic resilience drivers can worsen the state and the environmental balance. Only in the social dimension, the economic and social resilience drivers are cumulative and strengthen the welfare of society.

Starting from this analysis clear trade-offs emerge among the economic, social and ecological dimensions, highlighting the need for policies pointed to sustainability and equity. Territorial planning has to take into account two important goals, in order to achieve the conditions for sustainable development of local systems: the improvement of the ability to recover to adverse shocks and the containment of actions that could affect this capacity, causing a strong anthropic pressure on territorial assets. Empirical studies on vulnerability and resilience of regions represent useful instruments for the design of more effective hazard mitigation policies, oriented not to palliative but preventive measures.

First of all, place-based development policies are needed to address interventions on regional specificities, regarding the evidence of strong diversity across European regions. In this direction, the EU cohesion policies become essential to reduce the differences between countries and regions, especially in terms of infrastructure, education and green economy.

In particular, from the principal component analysis and the econometric test, the more relevant policy suggestions are the strengthening of innovation (R&D expenditures and employment in S&T sectors) and infrastructures for economic dimension, labor market interventions to contain unemployment and reinforce education for social dimension, and actions to defend biodiversity and woodland in environmental sphere in order to support economic, social and ecological resilience. But the emergence of trade-off between the three dimensions of sustainability requires integrated policies that aim at reaching an evolutionary balance of the various spheres of regional development. The emphasis on economic and industrial policies could actually facilitate economic recovery and resilience, but this would be at the expense of ecological and social balances.

From this point of view, an holistic representation of resilience capacity of territorial system and multi-hazard approach could represent a tool for policy making in order to achieve the system changes necessary for a sustainable territorial development (ICLEI 2016). Local governments and partners from the private sector have a great responsibility to invest in more resilient infrastructure, services and risk reduction strategies.

The next empirical work will explore linkages and reverse causality between resilience drivers and outcomes that will be represented by a broader batch of variables, connected with new themes such as social and institutional capital, inequality, environmental protection. The new steps of research would explore these cross-links with simultaneous equation models and latent variables, in order to better clarify the complex relationships and balances of territorial systems in the perspective of more targeted and balanced policies.

Appendix

See Tables 9 and 10.

Table 9 The selected variables of resilience in European Regions

Variable	Description	Units of measurements	Source	Time
Outcome variable				
GDP pc	GDP per capita in purchasing power parity	Euro	Eurostat	2000–2011 (mean)
Life expectancy	Life expectancy of population less than 1 year	Years	Eurostat	2000–2010 (mean)
CO_2 emissions[a]	CO_2 emissions per square kilometer of regional area	Ton per km^2	OECD	2008
Resilience drivers				
Gross Fixed Capital	Gross Fixed Capital per employee	Euro	Eurostat	2000–2010 (mean)
Employment in S&T sectors	Share of active population employed in science and technology	%	Eurostat	2008–2013 (mean)
Unemployment rate	Share of the labor force aged 15 years and over without work but available for and seeking employment	%	Eurostat	2000–2013 (mean)
Graduates	Weight of graduates on population	%	Eurostat	2000–2012 (mean)
R&D expenditures	Total intramural R&D expenditure	Euro per inhabitant	Eurostat	2000–2012 (mean)
Long-term unemployment	Share of unemployment which is long-term (12 years and over)	%	Eurostat	2000–2012 (mean)
Circulatory System death rate[a]	Share of deaths for circulatory disease	%	Eurostat	
Accidents death rate[a]	Share of deaths for transport Accident	%	Eurostat	2000–2010 (mean)
Neet[a]	People from 18 to 24 neither in employment nor in education and training	%	Eurostat	2000–2012 (mean)
Lifelong learning	Share of population from 25 to 64 in education and training (last 4 weeks)	%	Eurostat	2000–2012 (mean)
Biodiversity[a]	Landscape diversity expressed as Shannon Evenness Index	Index	OECD	2009
Wood land[a]	Woodland as share of land cover	%	Eurostat	2009
Urbanized areas[a]	Residential, economic and infrastructure related areas as share of land use	%	Eurostat	2009
Demographic balance	Total population change	%	Eurostat	2000–2012

[a] These variables are characterized by the presence of missing values. The approach to handle them is using the correspondent value at NUTS 1 level in the place of NUTS 2 one

Table 10 Economic, social, environmental Resilience Drivers Composite Indicator (rank)

Nuts code	Region	Econ. Res. rank	Soc. Res. rank	Env. Res. rank
AT11	Burgenland (AT)	184	102	51
AT12	Niederösterreich	156	88	30
AT13	Wien	13	75	237
AT21	Kärnten	126	74	8
AT22	Steiermark	108	73	5
AT31	Oberösterreich	114	60	22
AT32	Salzburg	99	58	48
AT33	Tirol	84	48	45
AT34	Vorarlberg	137	46	42
BE10	Région de Bruxelles-Capitale	8	154	246
BE21	Prov. Antwerpen	23	128	195
BE22	Prov. Limburg (BE)	75	150	168
BE23	Prov. Oost-Vlaanderen	40	108	204
BE24	Prov. Vlaams-Brabant	12	81	154
BE25	Prov. West-Vlaanderen	61	114	201
BE31	Prov. Brabant Wallon	5	140	200
BE32	Prov. Hainaut	115	235	166
BE33	Prov. Liège	77	198	151
BE34	Prov. Luxembourg (BE)	103	201	117
BE35	Prov. Namur	71	220	70
CZ01	Praha	14	71	224
CZ02	Strední Cechy	198	170	158
CZ03	Jihozápad	203	161	54
CZ04	Severozápad	239	222	81
CZ05	Severovýchod	210	168	65
CZ06	Jihovýchod	187	174	102
CZ07	Strední Morava	214	185	49
CZ08	Moravskoslezsko	206	193	20
DE11	Stuttgart	17	93	86
DE12	Karlsruhe	26	96	98
DE13	Freiburg	62	83	68
DE14	Tübingen	34	94	91
DE21	Oberbayern	6	90	122
DE22	Niederbayern	100	141	40
DE23	Oberpfalz	66	153	39
DE24	Oberfranken	140	152	7
DE25	Mittelfranken	38	121	83
DE26	Unterfranken	91	100	29
DE27	Schwaben	105	117	84
DE30	Berlin	25	119	222

Table 10 continued

Nuts code	Region	Econ. Res. rank	Soc. Res. rank	Env. Res. rank
DE40	Brandenburg	133	187	89
DE50	Bremen	47	113	242
DE60	Hamburg	9	89	241
DE71	Darmstadt	20	97	72
DE72	Gießen	78	123	11
DE73	Kassel	111	158	25
DE80	Mecklenburg-Vorpommern	146	191	76
DE91	Braunschweig	32	162	50
DE92	Hannover	68	169	112
DE93	Lüneburg	173	183	97
DE94	Weser-Ems	172	171	132
DEA1	Düsseldorf	80	138	170
DEA2	Köln	44	110	153
DEA3	Münster	142	134	92
DEA4	Detmold	117	145	120
DEA5	Arnsberg	143	143	75
DEB1	Koblenz	162	148	14
DEB2	Trier	107	135	18
DEB3	Rheinhessen-Pfalz	56	120	34
DEC0	Saarland	132	147	46
DED2	Dresden	51	172	95
DED4	Chemnitz	177	178	43
DED5	Leipzig	131	164	197
DEE0	Sachsen-Anhalt	174	196	103
DEF0	Schleswig-Holstein	112	125	140
DEG0	Thüringen	110	181	55
DK01	Hovedstaden	1	2	183
DK02	Sjælland	54	16	138
DK03	Syddanmark	52	7	111
DK04	Midtjylland	22	5	144
DK05	Nordjylland	27	9	125
EE00	Eesti	170	188	35
EL11	Anatoliki Makedonia, Thraki	225	246	74
EL12	Kentriki Makedonia	193	236	106
EL13	Dytiki Makedonia	208	243	33
EL14	Thessalia	216	242	113
EL21	Ipeiros	201	245	57
EL22	Ionia Nisia	248	214	47
EL23	Dytiki Ellada	212	241	36

Table 10 continued

Nuts code	Region	Econ. Res. rank	Soc. Res. rank	Env. Res. rank
EL24	Sterea Ellada	222	248	105
EL25	Peloponnisos	237	247	124
EL30	Attiki	155	223	178
EL41	Voreio Aigaio	218	238	190
EL42	Notio Aigaio	246	216	219
EL43	Kriti	204	218	161
ES11	Galicia	163	144	15
ES12	Principado de Asturias	136	156	44
ES13	Cantabria	145	106	108
ES21	País Vasco	43	78	41
ES22	Comunidad Foral de Navarra	48	65	137
ES23	La Rioja	130	139	174
ES24	Aragón	95	91	141
ES30	Comunidad de Madrid	30	66	173
ES41	Castilla y León	125	99	60
ES42	Castilla-La Mancha	186	109	172
ES43	Extremadura	190	137	119
ES51	Cataluña	106	105	159
ES52	Comunidad Valenciana	171	101	203
ES53	Illes Balears	192	98	220
ES61	Andalucía	181	155	160
ES62	Región de Murcia	185	129	205
ES63	Ciudad Autónoma de Ceuta	205	165	191
ES64	Ciudad Autónoma de Melilla	200	146	210
ES70	Canarias	183	95	202
FI19	Länsi-Suomi	39	57	28
FI1B	Helsinki-Uusimaa	2	4	69
FI1C	Etelä-Suomi	42	44	26
FI1D	Pohjois- ja Itä-Suomi	37	59	16
FI20	Åland	53	45	73
FR10	Île de France	7	69	198
FR21	Champagne-Ardenne	167	157	130
FR22	Picardie	150	177	157
FR23	Haute-Normandie	102	126	155
FR24	Centre	97	112	146
FR25	Basse-Normandie	141	116	167
FR26	Bourgogne	139	142	123
FR30	Nord - Pas-de-Calais	147	166	162
FR41	Lorraine	135	127	121
FR42	Alsace	70	82	142

Table 10 continued

Nuts code	Region	Econ. Res. rank	Soc. Res. rank	Env. Res. rank
FR43	Franche-Comté	96	124	93
FR51	Pays de la Loire	113	92	185
FR52	Bretagne	74	76	149
FR53	Poitou-Charentes	151	130	143
FR61	Aquitaine	87	111	126
FR62	Midi-Pyrénées	33	107	131
FR63	Limousin	123	104	32
FR71	Rhône-Alpes	45	86	128
FR72	Auvergne	81	115	104
FR81	Languedoc-Roussillon	72	179	156
FR82	Provence-Alpes-Côte d'Azur	64	131	148
FR83	Corse	69	175	177
HU10	Közép-Magyarország	144	205	169
HU21	Közép-Dunántúl	229	208	152
HU22	Nyugat-Dunántúl	234	206	116
HU23	Dél-Dunántúl	232	231	88
HU31	Észak-Magyarország	244	237	77
HU32	Észak-Alföld	230	234	133
HU33	Dél-Alföld	231	227	150
IE01	Border, Midland and Western	79	189	240
IE02	Southern and Eastern	35	151	234
ITC1	Piemonte	128	186	100
ITC2	Valle d'Aosta/Vallée d'Aoste	168	184	110
ITC3	Liguria	122	136	78
ITC4	Lombardia	104	132	186
ITF1	Abruzzo	165	182	56
ITF2	Molise	182	192	21
ITF3	Campania	194	225	96
ITF4	Puglia	202	217	139
ITF5	Basilicata	191	212	38
ITF6	Calabria	195	219	10
ITG1	Sicilia	196	230	115
ITG2	Sardegna	197	204	52
ITH1	Provincia Autonoma di Bolzano/Bozen	118	77	66
ITH2	Provincia Autonoma di Trento	73	79	118
ITH3	Veneto	161	118	165
ITH4	Friuli-Venezia Giulia	124	122	107
ITH5	Emilia-Romagna	83	133	136
ITI1	Toscana	164	149	109
ITI2	Umbria	166	160	61

Table 10 continued

Nuts code	Region	Econ. Res. rank	Soc. Res. rank	Env. Res. rank
ITI3	Marche	152	167	80
ITI4	Lazio	93	190	129
LU00	Luxembourg	10	70	145
NL11	Groningen	41	30	214
NL12	Friesland (NL)	116	38	226
NL13	Drenthe	138	54	134
NL21	Overijssel	82	28	181
NL22	Gelderland	58	25	184
NL23	Flevoland	29	20	231
NL31	Utrecht	11	3	230
NL32	Noord-Holland	21	12	235
NL33	Zuid-Holland	36	14	236
NL34	Zeeland	120	36	218
NL41	Noord-Brabant	46	26	192
NL42	Limburg (NL)	76	33	164
PL11	Lódzkie	220	229	37
PL12	Mazowieckie	159	200	85
PL21	Malopolskie	215	211	62
PL22	Slaskie	211	210	90
PL31	Lubelskie	227	199	94
PL32	Podkarpackie	236	226	53
PL33	Swietokrzyskie	247	232	24
PL34	Podlaskie	224	215	82
PL41	Wielkopolskie	226	221	135
PL42	Zachodniopomorskie	219	224	114
PL43	Lubuskie	242	209	64
PL51	Dolnoslaskie	213	202	87
PL52	Opolskie	240	213	63
PL61	Kujawsko-Pomorskie	245	228	99
PL62	Warminsko-Mazurskie	233	233	67
PL63	Pomorskie	207	194	101
PT11	Norte	243	173	23
PT15	Algarve	217	207	147
PT16	Centro (PT)	238	176	9
PT17	Lisboa	149	180	163
PT18	Alentejo	223	203	2
PT20	Região Autónoma dos Açores	221	197	13
PT30	Região Autónoma da Madeira	209	195	27
SE11	Stockholm	3	1	59
SE12	Östra Mellansverige	24	18	31

Table 10 continued

Nuts code	Region	Econ. Res. rank	Soc. Res. rank	Env. Res. rank
SE21	Småland med öarna	90	21	3
SE22	Sydsverige	16	15	71
SE23	Västsverige	15	8	58
SE31	Norra Mellansverige	98	53	1
SE32	Mellersta Norrland	67	52	4
SE33	Övre Norrland	28	31	12
SI01	Vzhodna Slovenija	180	159	6
SI02	Zahodna Slovenija	65	84	17
SK01	Bratislavský kraj	60	163	171
SK02	Západné Slovensko	235	239	127
SK03	Stredné Slovensko	228	240	19
SK04	Východné Slovensko	241	244	79
UKC1	Tees Valley and Durham	169	63	238
UKC2	Northumberland and Tyne and Wear	158	34	187
UKD1	Cumbria	176	80	211
UKD3	Greater Manchester	127	35	244
UKD4	Lancashire	148	41	233
UKD6	Cheshire	19	64	216
UKD7	Merseyside	94	87	243
UKE1	East Yorkshire and Northern Lincolnshire	188	67	232
UKE2	North Yorkshire	88	40	223
UKE3	South Yorkshire	175	55	225
UKE4	West Yorkshire	157	51	239
UKF1	Derbyshire and Nottinghamshire	121	43	229
UKF2	Leicestershire, Rutland and Northamptonshire	134	29	221
UKF3	Lincolnshire	189	72	228
UKG1	Herefords., Worcestershire and Warwickshire	101	49	189
UKG2	Shropshire and Staffordshire	178	47	213
UKG3	West Midlands	153	56	245
UKH1	East Anglia	59	42	209
UKH2	Bedfordshire and Hertfordshire	49	19	217
UKH3	Essex	109	27	227
UKI1	Inner London	4	22	248
UKI2	Outer London	85	17	247
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	18	11	206
UKJ2	Surrey, East and West Sussex	63	10	176
UKJ3	Hampshire and Isle of Wight	57	6	199
UKJ4	Kent	129	50	215
UKK1	Gloucestershire, Wiltshire and Bristol	50	13	207

Table 10 continued

Nuts code	Region	Econ. Res. rank	Soc. Res. rank	Env. Res. rank
UKK2	Dorset and Somerset	154	24	196
UKK3	Cornwall and Isles of Scilly	199	68	193
UKK4	Devon	160	23	175
UKL1	West Wales and The Valleys	179	61	182
UKL2	East Wales	86	32	208
UKM2	Eastern Scotland	55	37	179
UKM3	South Western Scotland	92	62	188
UKM5	North Eastern Scotland	31	39	180
UKM6	Highlands and Islands	119	85	194
UKN0	Northern Ireland	89	103	212

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