Romanian Journal of Regional Science
Vol. 13, No. 1, Summer 2019

SPATIO-TEMPORAL ANALYSIS OF RESILIENCE DURING THE GREAT RECESSION. THE CASE OF ITALY

Barbara Martini*, Marco Platania

Department of Enterprise Engineering, University of Rome Tor Vergata
via Columbia 2, 00133 Rome, Italy
E-mail: barbara.martini@uniroma2.it
*Corresponding author

Biographical Notes

Barbara Martini Ph.D. is researcher of Applied Economics at University of Rome Tor Vergata (Italy). Her fields of interest concern social and economic resilience, spatial econometrics and regional economics. She teaches International Economics at Temple University Rome (TUR).

Marco Platania Ph.D. is researcher of Applied Economics at University of Catania (Italy). His research interests are related to economic resilience, regional economics and tourism economics.

Abstract

The 2007 economic shock had a strong impact in Italy, hampering the efforts to reduce the regional disparities. Using the concept of resilience, the aim of the paper is twofold: first, to explore the resilience regional determinants; second, using a spatio-temporal approach, to analyze if resilience is not only a regional attribute, but also a process influenced by the geographical localization. Results highlight that Italy is polarized in two clusters: the first one composed by resilient regions and a second one grouping the non-resilient regions. The first one, the more dynamic, has been able to resist and recover after the shock, while the latter one has been trapped in a less dynamic and less competitive socio-economic model. This polarization not only remains after the shock, but it becomes stronger.

Keywords: resilience, regional disparities, spatial panel model, Italy
JEL Classification: R10, R12, C23, C33

1. Introduction

Resilience, the ability of a system to withstand and recover after a shock, is a quite popular concept and, for the time being, it is used in several fields such as engineering and ecology. Recently, this approach has also been used in the social sciences, especially in the economic and regional field, creating a large body of literature. "Despite the notable theoretical and empirical achievements made by scholars studying economic resilience, some unsettled aspects request further investigation" (Di Caro and Fratesi, 2018, p.236). Two main lines of research can be identified (Cellini and Torrisi, 2014). The first one studies the effects of "great shocks" on the growth of cities (Bosker et al., 2007) and a second line of research includes analyzes on regional growth and on how regions respond to national and / or international economic shocks (Simmie and Martin, 2010). Recent contributions by Fingleton, Garretsen and Martin (2012) and Martin (2012) clarify how resilience can provide an interesting reading key for understanding the differences between territories.

After a seven-year cycle of moderate growth, the international crisis has pushed Italy into the deepest recession of the last 50 years of its history. Italy was the first country in the Euro Area to record a downturn already in 2008 (Fabbris and Michielin, 2010). The difficulties of the Italian economy have a distant origin. Between the mid-90s and 2007, the average annual growth rate of GDP (1.5 per cent) was just over half that of the euro-area countries (2.5 per cent). Similarly, labor productivity developments followed a substantially similar trend and this happened because of the difficulties with which Italy faced the important changes that were taking place in the global context: the change in the technological paradigm caused by new information and communication technologies, the global integration of real and financial markets, the emergence of large rapidly developing economies, the tendency to a geographical segmentation of production on a global scale (Signorini, 2013). The strong cyclical contraction of international trade primarily penalized the central northern regions, which were more export-oriented. However, subsequent economic trends have reflected the advantages of the most competitive areas, with better access to international markets (Signorini, 2013).

The aim of the paper is to identify the determinants of regional resilience in Italy at socio-economic level through a spatio-temporal analysis.

The paper is organized in the following way: in the first part, the concept of resilience will be examined in relation to the regional context. In the second part, the methodology and the main results of the survey will be presented. Some final considerations conclude the work.

2. Literature review

The concept of resilient has evolved considerably since Holling's (1973) seminal paper and it has attracted the attention from regional analysts and economic geographers only recently. In one of the pioneering study, Reggiani et al. (2002) argued that the notion of "resilience" could be a key aspect of the dynamics of spatial economic systems, especially concerning how such systems respond to shocks, disturbances, and perturbations. As a consequence, the notion of resilience not only can be adopted in a scientific context, but it can also be used in a socio-economic system where resilience can be seen as a conceptual framework and regions can be represented in a dynamic and holistic way, in which social and economic components are interrelated (Swanstrom, 2008).

The growing interest for the notion of resilience and the socio-economic system has been stimulated by several factors (natural disasters, terroristic attacks, economic shocks). After the 2007 economic shock, resilience received a growing interest as response to a generalized sense of uncertainty and insecurity from the perception that processes associated with globalization have made places and regions more permeable to the effects of what were once thought to be external processes and it has been seen as an answer to the search for formulas for adaptation and survival (Christopherson et al., 2010).

Resilience, the ability of a system to deal with a shock, can be interpreted using three different approaches: *engineering* – the ability of a system to return to its state of equilibrium after the shock, *ecological* – the scale of shock that a system is able to absorb before moves to a different state, and, finally, and *adaptive approach*- ability of the system to reorganize its form or functions (Martin, 2012).

Resilience literature is wide and it can be ideally divided in two lines. The first one, prior 2008, focalized the attention on dynamics of complex, adaptive, social-ecological systems (SES) - the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change (Holling 1973; 1996; 2001; Gunderson, 2000; Adger, 2000; Walker et al., 2004; Carpenter et al., 2005). Following this approach resilience is a process (Pendall et al., 2007) and it includes those inherent conditions that allow the system to absorb impacts and disturbance and cope with an event, as well as post-event. Moreover, it is an adaptive process that facilitates the ability of the social system to re-organize, change, and learn in response to a threat (Cutter et al., 2008) and reorganize while undergoing change, so as to still retain

essentially the same function, structure, identity, and feedbacks (Walker and Mayers, 2004). These contributions take into consideration not only the economic components of a system, but also the social ecological ones.

A second wave of contribution started with a special issue of Cambridge Journal of Regions, Economy and Society (2010) and is mainly focalized on the economic resilience after the 2007 economic shock and it can be ideally split in two different lines. The first one, focused on the spatial asymmetry in the reaction to the 2007 economic shock (Cellini and Torrisi, 2014; Crescenzi et al., 2016; Fingleton et al., 2012; Martin, 2012) and a second one, regarding the determinants of regional resilience (Lee, 2014, Martin et al., 2016; Fratesi and Perrucca, 2017). These contributions consider resilience as a process including, as part of the analysis, not only the consequences of the shock, but also the previous regional situation.

At this point, a definition of resilience it is necessary. Following Martin (2012), resilience can be defined as the ability of a system to withstand, cope with or recover after a shock. In accordance with this definition, resilience is a multifaceted process made by four interrelated dimensions: resistance- the degree of sensitivity or depth reaction to the shock-, recovery – the speed and the degree of recovery after the shock-, re-orientation – adaptability of regional economy in response to the shock-, renewal- the extent to which regional economy renews its pre shock growth path or hysteretic shift to new growth path (Martin, 2012). The way whereby these dimensions are interrelated is still unexplored in literature. In order to focus not only on the reaction to the shock, but also on the consequences, we will define resilience as the ability of a region to reconfigure their socio-economic and institutional structure to develop new growth path (Bosham, 2015). This definition is wide enough and it has the advantage to underlying the importance of the social components in regional resilience. In accordance with the definition of resilience, our starting point is represented by the idea the resilience is a process (Pendall, Foster and Cowell, 2007) and the ability to reconfigure the social economic structure will depend also from the choices made during the past (Gardiner et al., 2013 for UK, Lagravinese, 2015 for Italy, Cuadraro-Roura and Maroto, 2016 for Spain).

The shock definition is important to be identified. Shocks can be different for severity and length and they can impact in different ways across different regions. Moreover, different shocks generate different reactions and, as a consequence, different levels of resilience (Martin et al., 2016). Therefore, resilience cannot be considered as a fixed attribute of a region (Martin, Sunley and Tyler, 2015). The shock is the 2007 economic shock, considered as the deepest crises since 1930s, and it has severely hit Italian regions. Our intent is not only to analyse the impact of

economic crises on Italian regions, but also to contribute in understanding what determines the regional resilience and what makes it more or less resilient.

These objectives are related to the comprehension of the spatial effects in the resilience framework. In fact, both natural and man-made disasters can have various spatial effects. Investigating these phenomena is a complex, but very strategic problem for identifying spatial configurations that can allow greater resilience. Space - considered as a container of actions - plays a significant role in this sense because within the "spatial economy" we are able to unite the spatial and economic processes characterized by high levels of uncertainty, and uncertainty is at the centre of resilience (Caschili et al., 2015).

In order to predict and minimize the substantial economic losses generated by disruptive events, the attention of scholars is now turning to the resilience of economic space systems (Rose, 2009).

3. Resilience determinants: the model

The aim of the empirical analysis is to identify the determinants of regional resilience using a spatial-temporal analysis. Several methods are used to measure the reaction capacity of a regional economic system. In our work, we will refer to the approach used by Cuadraro-Roura and Maroto (2016) who consider resilient regions those that independently of the gross domestic product (GDP) per capita before the shock, have been able, after the shock, to have a GDP growth rate per capita higher than the national average.

Our analysis aims to overcome the idea that resilience is only a regional phenomenon, but it will depend also from geographical localization. Among spatial units, there may be a spatial dependence i.e. a functional relationship between what happens at one point in space and what happens elsewhere. Spatial effects such as spatial heterogeneity and spatial dependence should be taken into consideration in order to explore resilience not only as a regional attribute, but also as a consequence of the geographic localization. Spatial panels refer to geo-referenced data over time (Baltagi and Li, 2004; Elhorst, 2014; Elhorst, 2017), which simultaneously consider both the spatial and temporal elements using spatio-temporal analysis.

The model includes in the analysis the main macroeconomic variables of aggregate demand, such as private investments and net imports (import-export) (Dormady et al., 2019). Moreover, other variables have been added in order to explain resilience. In particular, some technological ones have been included, such as number of patents and R&D expenditure. Spending on R&D is an economic variable linked to patent intensity. The value of R&D represents the input of a production function whose output is the number of patents. Patent and R&D expenditure are closely related.

Despite this, as pointed by Bilbao-Osorio and Rodriguez-Pose (2004), the impact of R&D on innovation (captured by patent) can follow different paths depending on the typology of R&D investment. Our analysis will take into consideration the total R&D expenditure that includes both the public and the private component. The Italian regions are characterized by the well-known north-south dichotomy in which the incidence of R&D expenditure in the private sector is higher in the north, while the south is characterized by a higher incidence of public spending on R&D.

The model also includes a financial variable, the financing risk (RF), which captures the effects of the credit market, which is often included among the indicators that can explain resilience (Modica and Reggiani, 2015). This variable corresponds to the ratio between the amount of non-performing bank loans and the amount of credits disbursed by the banking system. The higher is the RF indicator the lower is the firm reliability. Moreover, regional specialization, captured in the model through the Local Quotient constructed using employment in the sectors of agriculture, industry, construction and services, will be taken into consideration (Martin et al., 2016, Lagravinese, 2015).

Finally, variables for social dimension are added. The choice of social resilience indicators is debated in the literature (Modica and Reggiani, 2015; Camagni, 2009; 2017). Following these authors, the school dropout rate and the number of STEM (graduates in scientific and technological disciplines) were considered as social resilience covariates. These variables do not provide a complete view of the regional social and cultural dimension, but, in accordance with the parsimony principle, and in order to avoid phenomena such as latent endogeneity and collinearity, we will focus on these particular aspects that appear to be consistent with the objectives of the present work. The school dropout rate is actually a proxy for a condition of social hardship, while STEM graduates capture the "technological" supply component of human capital.

The description of the variables is shown in Table 1.A in the appendix. The model is described by the following equation (1)

$$\ln(\mathrm{GDP}_{it}) = NI_{it} + STEM_{it} + I_{it} + ABB_{it} + IB_{it} + RF_{it} + RD_{it} + LQa_{it} + LQi_{it} + LQc_{it} + LQs_{it} + \varepsilon_{it} \quad (1)$$

where i is the region (Bolzano e Trento, that are a special province, are considered NUTS 2) and t time $1998 \leq t \leq 2012$. The period under consideration (1998-2012) can be divided into two sub-periods; the first, prior to the economic shock (1998-2007) and the second, indicated as a period during the crisis that refers to the years 2008-2012.

In order to analyze the resilience determinants, a Cliff-Ord (Cliff and Ord 1973; 1981; Kelejian and Prucha, 1997) Spatial Error Model (SEM) will be considered. Moreover, error will be

modelled using the Baltagi (Baltagi and Li, 2004) specification, where the spatial component is on the error term. Finally, the model will be estimated using the R software with the package spml (Millo and Piresi, 2012). A fixed effect model has been used in accordance with Elhorst (2014) and the Hausman test with spatial panel data specification proposed by Mult and Pfaffermayr (2011). The model is the following:

$$y_{it} = X'_{it}\beta + \mu_{it} \quad (2)$$

The residuals are spatially auto correlated:

$$u_t = \mu + \varepsilon_t \quad (3)$$

with $\varepsilon_t = \lambda W \varepsilon_t + \nu_t$ where $u'_t = (u_{t1} \dots . u_{tN})$ and $\varepsilon'_t = (\varepsilon_{t1} \dots . \varepsilon_{tN})$.

$\mu'_t(\mu_1 \dots . \mu_N)$ is a vector of regional random effects $IIN(0; \sigma_\mu^2)$, λ is the spatial coefficient, with $|\lambda| < 1$ and W is the spatial weight matrix, NxN, where the diagonal elements are equal to 0.

The estimates will be conducted for the regions as a whole, for the subset of the resilient regions and for the subset of the non-resilient regions.

3.1. Italian regional resilience

As previously discussed, in accordance with Cuadraro-Roura and Maroto (2016), the resilient regions are those that, independently of the gross domestic product (GDP) per capita before the shock, have been able, after the shock, to have a GDP growth rate per capita higher than the national average. The results are displayed in Figure 1.

Regions located in the first quadrant, at the top right, are characterized by a high level of GDP and a growth of the same above the national average. The regions that fall in the second quadrant, in the upper left, have a lower GDP level than the national average, but a higher growth rate. The regions that have a GDP level and a growth rate lower than the national average belong to the third quadrant, bottom left. In the fourth quadrant, at the bottom right, are the regions with a GDP level higher than the national average and a growth rate that is lower than the national average.

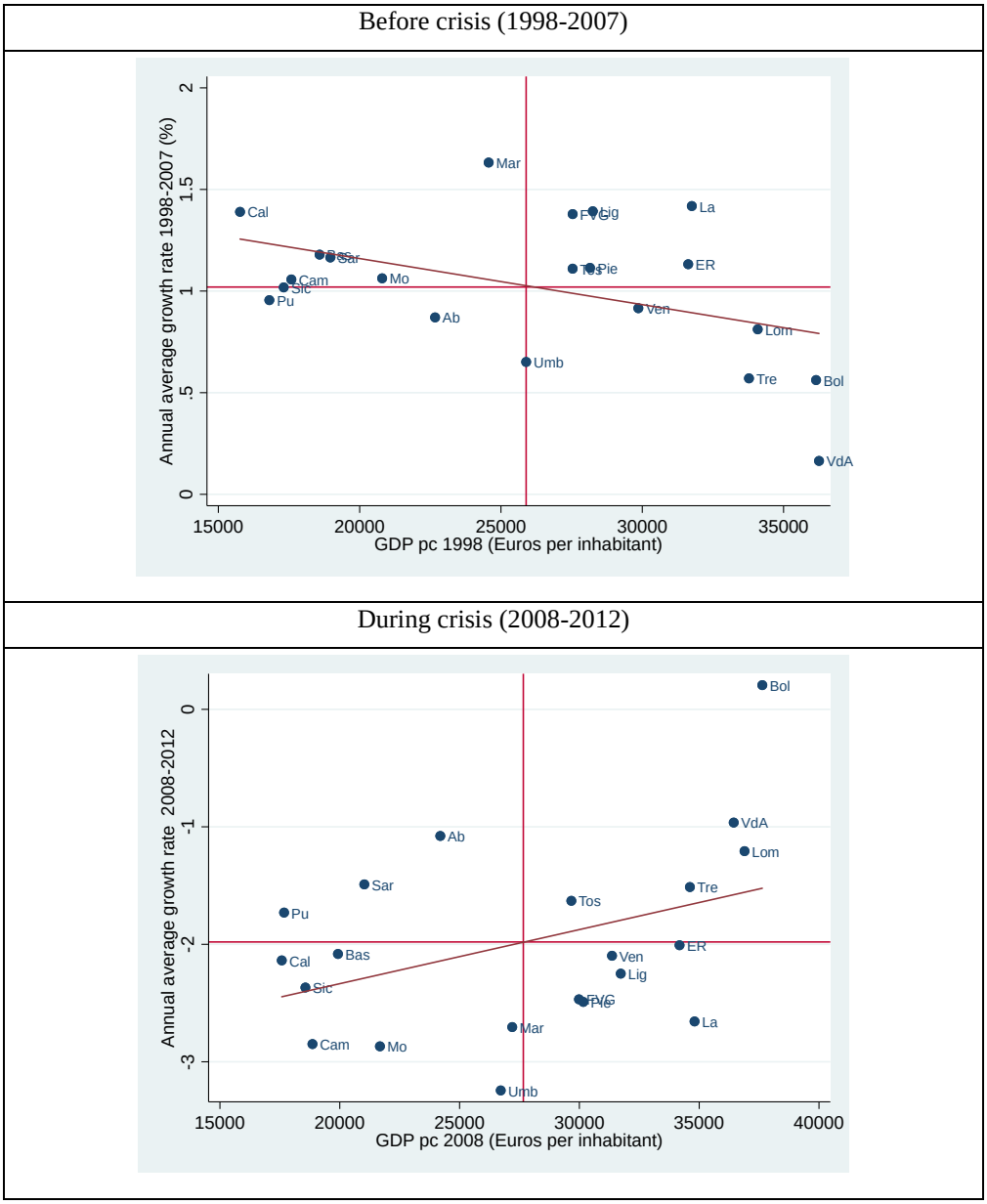
During the period 1998-2007, the Italian regions with a GDP level below the national average had a period of high growth, while, after the 2007 shock, this process was completely reversed: the regions with a low GDP level per capita had a lower level of growth than the national average, while regions with a high level of income had growth above the average national growth rate.

In the period between 2008 and 2012 the Gross Domestic Product (GDP), measured in volume, marked a rather diversified dynamic at the territorial level, with a less marked reduction compared to the national average in the Center and North (-7.0%), and much more accentuated in

the South (-13.1%). During the modest recovery of 2010-11, the Central North's GDP increased, cumulatively, by 3.2 per cent, while that of the Southern regions decreased further (-0.8 per cent), also due to the traditional greater dependence of this area on public demand. In 2012 the product of the southern regions fell by 2.9 per cent, compared to -2.4 per cent in the Center and North.

Overall, the regions that had, in the period following the shock, a GDP growth rate higher than the national average were Tuscany, Valle d'Aosta, Lombardy, Trento and Bolzano, Sardinia, Abruzzo and Puglia.

Figure 1. Average annual growth rate and per capita GDP 1998-2007; 2008-2012



Notes: Pie=Piemonte; VdA=Valle d'Aosta; Lig=Liguria; Lom=Lombardia; Bol=Bolzano; Tre=Trento; Ven=Veneto; FVG=Friuli Venezia Giulia; ER=Emilia Romagna; Tos=Toscana; Umb=Umbria; Mar=Marche; La=Lazio; Ab=Abruzzo; Mo=Molise; Cam=Campania; Pu=Puglia; Bas=Basilicata; Cal=Calabria; Sic=Sicilia; Sar=Sardegna

Source: own elaboration on ISTAT (2019) data

3.2. The spatial analysis

Estimated results are summarized in Table 1.

Table 1. SEM Spatial Panel Fixed Effect

dep. Variable= ln(GDP)						
	1998-2007			2008-2012		
	all data-set	non-resilient	resilient	all data-set	non-resilient	resilient
ni	-7.4688e-03***	-6.1645e-03***	-0.0072556***	-6.3474e-03***	-0.00382897***	-8.8318e-03***
	(< 2.2e-16)	(7.748e-16)	(< 2.2e-16)	(5.557e-14)	(0.0006874)	(< 2.2e-16)
stem	2.9860e-03***	1.9664e-03*	1.4973e-03**	-1.1320e-03	-0.00125309	-4.0004e-04
	(2.535e-08)	(0.012039)	(0.008739)	(0.1813373)	(0.4340173)	(0.4802495)
i	1.0253e-02***	9.4105e-03***	8.1212e-03***	7.7337e-03***	0.00523847**	1.2412e-02***
	(< 2.2e-16)	(1.779e-10)	(6.646e-09)	(2.976e-08)	(0.0020049)	(< 2.2e-16)
abb	-2.9606e-03***	-1.0167e-03	-2.0587e-04	6.0769e-04	0.00132281	-7.0164e-04
	(0.0002407)	(0.343284)	(0.817072)	(0.6429369)	(0.4670516)	(0.5769389)
ib	1.8853e-04*	1.6673e-05	2.1202e-04*	1.1778e-05	-0.00011296	2.2547e-04***
	(0.0371164)	(0.899568)	(0.022751)	(0.8947729)	(0.3008158)	(0.0007071)
rd	-3.8836e-03	-4.6734e-02**	8.2258e-03	-1.2034e-02	0.00921673	2.5566e-02^{+}
	(0.7828797)	(0.006261)	(0.675912)	(0.5368277)	(0.7308012)	(0.0753217)
rf	5.5251e-05	5.9910e-04	-3.4627e-03	-2.4678e-04	0.00106207	-4.1990e-03***
	(0.9468942)	(0.475595)	(0.058509)	(0.7553301)	(0.2306075)	(0.0001990)
lqa	1.4679e-02**	1.6333e-02**	3.6796e-03	7.0900e-03	0.03378824*	-3.8958e-02*
	(0.0098711)	(0.004971)	(0.773002)	(0.6332937)	(0.0344240)	(0.0123032)
lqi	-2.7855e-02	3.5401e-02	-5.8040e-02	5.0819e-02	0.16733173***	-3.0409e-02
	(0.2873393)	(0.287252)	(0.294432)	(0.1602605)	(0.0001091)	(0.5006120)
lqc	1.7460e-02	2.1744e-02	1.4430e-02	8.1591e-02***	0.06975741**	-3.0137e-02
	(0.1280476)	(0.120306)	(0.459246)	(0.0004976)	(0.0087197)	(0.3173064)
lqs	7.2920e-02*	5.8142e-02	-2.4363e-02	6.5018e-02	0.08385514	1.4353e-01
	(0.0256943)	(0.240668)	(0.593983)	(0.3214876)	(0.2124093)	(0.1880051)
Spatial autoregressive coefficient						
λ	0.710739***	0.808529***	0.77424***	0.794114***	0.840892***	0.815131***
	(< 2.2e-16)	(< 2.2e-16)	(< 2.2e-16)	(< 2.2e-16)	(< 2.2e-16)	(< 2.2e-16)
P value in parenthesis; ***0.001;**0.01; *0.05, $^{+}$0.1						

The spatial component (λ) is positive and significant both in the antecedent period and in the period following the shock in all the cases considered, highlighting a strong regional connection in terms of unobserved variables that the shock of 2007 has strengthened. With regard to covariates, net exports and private investments are significant and correctly determined in the positive sign to indicate that the gross domestic product of the Italian regions is driven, both before and after the

economic shock, by these two components. Moreover, before the shock, STEM graduates have a positive and significant impact on GDP, while after the shock they lose their significance.

This result underlines a structural change of behavior of the Italian regions after the shock. The school dropout component is correctly determined in the sign and is significant only in the period before the shock for the entire dataset. The patent intensity is positive and significant in the resilient regions both in the period before the shock and in the following period. The GDP of resilient regions is therefore explained also through the patent intensity that represents a proxy for the ability to innovate. To reinforce this result, there is evidence obtained in terms of R&D: in the resilient regions it is positive and significant after the shock, while in the non-resilient regions, before the shock, it is negative and significant. Since R&D spending includes both public and private spending on research, it is reasonable to assume that public spending on R&D is made in less dynamic and innovative regions and that it is then used in the most dynamic regions even in terms of patents.

As far as the productive specialization is concerned, the specialization in industry and construction is significant and positive only in the non-resilient regions after the shock.

From this model emerges a strongly polarized regional picture with two clusters that tend to become stronger. On the one hand, the resilient regions, characterized by innovative capacity and a healthy productive fabric (RF is negative and significant), on the other a second cluster of regions, the non-resilient ones, which remained trapped in an obsolete production model. In this model, the determinants of GDP, in addition to those typical of aggregate demand - net imports and investments, are mostly connected to a productive specialization in industry and construction. This process also tends to strengthen over time.

4. Discussion and conclusion

The paper aimed to identify the determinants of regional resilience in Italy at socio-economic level through a spatio-temporal analysis. The results highlight not only the presence of the well-known dualism between North and South, but also a regional clustering between resilient and non-resilient regions. In both clusters, GDP is explained by net import and private investments. Moreover, in the resilient regions, the GDP is also driven by innovation, R&D and patents (IB) are both positive and significant after the 2007 economic shock.

The human capital, by contrast, plays an important role before the shock, but it is not significant after the shock. This result underlines the structural break occurred afterward the shock. Finally, the financial risk (RF) underlines the presence of a healthy and trustable system of firms in resilient regions. These regions, after the shock, have found new and more promising paths of

growth based on innovation. Non-resilient regions, by contrast, are trapped in a productive structure mainly specialized in industrial and construction sector, severely hit by shock.

The dichotomy between resilient and non-resilient regions tends to be exacerbated after the shock, the spatial term increases in magnitude. Resilience depends not only on regional characteristics, but also on geographic localization and spatiality. This result overcomes the idea that resilience is a regional attribute. Moreover, spatial dependence contributes to create a self-reinforcing cluster. This result has several consequences in term of policy. Creating a resilient region does not depend only on regional policies, but also on supra-regional policies. Finally, our model (SEM) considers the spatial term in the error. This hypothesis is linked to the idea the resilience is a multi-faced and often unobservable. The results confirm this hypothesis and highlight the presence of unobservable variables. Further research in terms of exploring the resilience spatial components, also in terms of spatial spillover is needed.

References

Adger, W.N., 2000. Social and ecological resilience: are they related?. *Progress in Human Geography*, [e-journal] 24, pp. 347-364. Doi: 10.1191/030913200701540465

Baltagi, B.H. and Li, D., 2004. Prediction in the panel data model with spatial autocorrelation. In: L. Anselin, R. Florax and S. J. Rey eds., 2000. *Advanced in spatial econometrics: methodology, tools and applications*. Berlin: Springer, pp. 283-295.

Bilbao-Osorio, B. and Rodriguez-Pose, A., 2004. From R&D to innovation and economic growth in the EU. *Growth and Change*, [e-journal] 35(4), pp. 434-455. Doi: 10.1111/j.1468-2257.2004.00256.x

Bosham, R., 2015. Towards an evolutionary perspective on regional resilience. *Regional Studies*, [e-journal] 49(5), pp. 733-751. Doi: 10.1080/00343404.2014.959481

Bosker, M., Brakman, S., Garretsen, H. and Schramm, M., 2007. Looking for multiple equilibria when geography matters: German city growth and the WWII shock. *Journal of Urban Economics*, [e-journal] 61(1), pp. 152-169. Doi: 10.1016/j.jue.2006.07.001

Camagni, R., 2009. Territorial capital and regional development. In: R. Capello and P. Nijkamp eds., 2009. *Handbook of regional growth and development.* Cheltenham: Edwar Elgar Publishing. pp. 118-132

Carpenter, S.R., Westley, F. and Turner, M.G., 2005. Surrogate for resilience of social-ecological systems. *Ecosystem*, [e-journal] 8, pp. 941-944. Doi: 10.1007/s10021-005-0170-y

Caschili, S., Reggiani, A. and Medda, F., 2015. Resilience and vulnerability of spatial economic networks. *Networks and Spatial Economics*, [e-journal] 15(2), pp. 205-210. Doi: 10.1007/s11067-015-9283-9

Cellini, R. and Torrisi, G., 2014. Regional resilience in Italy: a very long run analysis. *Regional Studies,* [e-journal] 48(11), pp. 1779-1796. Doi: 10.1080/00343404.2013.861058

Christopherson, S., Michie, J. and Tyler, P., 2010. Regional resilience: theoretical and empirical perspectives. *Cambridge Journal of Regions, Economy and Society,* [e-journal] 3(1), pp. 3-10. Doi: 10.1093/cjres/rsq004

Cliff, A. and Ord, J., 1973. *Spatial autocorrelation*. London: Pion.

Cliff, A. and Ord, J., 1981. *Spatial process: models and applications*. London: Pion.

Crescenzi, R., Luca, D. and Milio, S., 2016. The geography of the economic crises in Europe: national macroeconomic conditions, regional structural factors and short term economic performance. *Cambridge Journal or Regions Economic and Society,* [e-journal] 9(1), pp. 13-32. Doi: 10.1093/cjres/rsv031

Cuadraro-Roura, J.R. and Maroto, A., 2016. Unbalanced regional resilience to the economic crisis in Spain: A tale of specialization and productivity. *Cambridge Journal of Regions, Economy and Society,* [e-journal] 9(1), pp. 153-178. Doi: 10.1093/cjres/rsv034

Cutter, S.L., Burnes, L., Berry, M., Burton, C. et al., 2008. A place-based model for understanding community resilience to natural disaster. *Global Environmental,* [e-journal] 18(4), pp. 598-606. Doi: 10.1016/j.gloenvcha.2008.07.013

Di Caro, P. and Fratesi, U. 2018. Regional determinants of economic resilience. *Annals of Regional Science,* [e-journal] 60(2), pp. 235-240. Doi: 10.1007/s00168-017-0858-x

Dormady, N., Roa-Henriquez, A. and Rose, A., 2019. Economic resilience of the firm: A production theory approach. *International Journal of Production Economics,* [e-journal] 208, pp. 446-460. Doi: 10.1016/j.ijpe.2018.07.017

Elhorst, J.P., 2014. *Spatial econometric. From cross-sectional data to spatial panel*. S.l: Springer.

Elhorst, J.P., 2017. Spatial panel data analysis. In: S. Shekhar, Xi H. Xiong and X. Zhou eds., 2017. *Encyclopedia of GIS*. S.l: Springer, pp. 2050-2058

Fabbris, T. and Michielin, F., 2010, *The economy of the Italian regions: recent developments and responses to the economic crisis*. [pdf] Directorate-General for Regional Policy Working Paper 01/2010. Available at: <http://ftp.infoeuropa.eurocid.pt/database/000047001-000048000/000047616.pdf> [Accessed 3 February 2019].

Fingleton, B., Garretsen, H. and Martin, R., 2012. Recessionary shocks and regional employment: evidence on the resilience of UK regions. *Journal of Regional Science,* [e-journal] 52(1), pp. 109-133. Doi: 10.1111/j.1467-9787.2011.00755.x

Fratesi, U. and Perrucca, G., 2017. Territorial capital and the resilience of European regions. *The Annals of Regional Science,* [e-journal] 60(2), pp. 241-264. Doi: 10.1007/s00168-017-0828-3

Gardiner, B., Martin, R., Sunley, P. and Tyler, P., 2013. Spatially unbalanced growth in the British economy. *Journal of Economic Geography,* [e-journal] 13(6), pp. 889-928. Doi: 10.1093/jeg/lbt003

Gunderson, L.H., 2000. Ecological resilience - In theory and application. *Annual Reviews of Ecology and Systematics,* [e-journal] 31, pp. 425-439. Doi: 10.1146/annurev.ecolsys.31.1.425

Holling, C.S., 1973. Resilience and stability of ecological system. *Annual Review of Ecology and Systematics,* [e-journal] 4, pp. 1-23. Doi: 10.1146/annurev.es.04.110173.000245

Holling, C.S., 1996. Engineering resilience versus ecological resilience. In: P. Schulze ed., 1996. *Engineering within ecological constraints*. Washington D.C.: National Academy Press, pp. 31-44.

Holling, C.S., 2001. Understanding the complexity of economic, ecological and social system. *Ecosystem,* [e-journal] 4, pp. 390-405. Doi: 10.1007/s10021-001-0101-5

ISTAT, 2019. *I.Stat*. [online] Available at: <http://dati.istat.it/> [Accessed 3 February 2019].

Kelejian, H.H. and Prucha, I.R., 1998. A generalized spatial two stage least square procedure for estimating a spatial autoregressive model with autoregressive disturbance. *Journal of Real Estate Finance and Economics,* [e-journal] 17(1), pp. 99-121. Doi: 10.1023/A:1007707430416

Lagravinese, R., 2015. Economic crises and rising gap north south: evidence from Italian regions. *Cambridge Journal of Regions Economy and Society*, [e-journal] 8(2), pp. 331-342. Doi: 10.1093/cjres/rsv006

Lee, N., 2014. Grim down South? The determinants of unemployment increases in British Cities in 2008-2009 recession. *Regional Studies,* [e-journal] 48(11), pp. 1761-1778. Doi: 10.1080/00343404.2012.709609

Martin, R., Sunley, P. and Tyler, P., 2015. Local growth evolution: recession, resilience, recovery. *Cambridge Journal of Regions, Economy and Society*, [e-journal] 8, pp. 141-148. Doi: 10.1093/cjres/rsv012

Martin, R., 2012. Regional economic resilience, hysteresis and recessionary shocks. *Papers in Evolutionary Economic Geography*, [e-journal] 12(1), pp. 1-32. Doi: 10.1093/jeg/lbr019

Martin, R., Sunley, P., Gardiner, B. and Tyler, P., 2016. How regions react to recession: resilience and the role of economic structure. *Regional Studies,* [e-journal] 50(4), pp. 561-585. Doi: 10.1080/00343404.2015.1136410

Millo, G. and Piresi, G., 2012. SPML: spatial panel data model in R. *Journal of Statistical Software,* [e-journal] 47(1), pp. 1-38. Doi: 10.18637/jss.v047.i01

Modica, M. and Reggiani, A., 2015. Spatial economic resilience: overview and perspectives. *Networks and Spatial Economics*, [e-journal] 15(2), pp. 211-233. Doi: 10.1007/s11067-014-9261-7

Mult, J. and Pfaffermayr, M., 2011. The Hausman Test in a Cliff and Ord panel model. *The Journal of Econometrics*, [e-journal] 14(1), pp. 48-76. Doi: 10.1111/j.1368-423X.2010.00325.x

Pendall, R., Foster, K. A. and Cowell, M., 2007. *Resilience and regions: building understanding of the methaphor*. [pdf] UIRD Working Paper Series. Available at: <https://www.econstor.eu/bitstream/10419/59385/1/59284076X.pdf> [Accessed 3 February 2019].

Reggiani, A., de Graaff, T. and Nijkamp, P., 2002. Resilience: an Evolutionary Approach to Spatial Economic System. *Networks and Spatial Economics*, [e-journal] 2(2), pp. 211-229. Doi: 10.1023/A:101537751

Rose, A.Z., 2009. A framework for analyzing the total economic impacts of terrorist attacks and natural disasters. *Journal of Homeland Security and Emergency Management*, [e-journal] 6(1), art. 9. Doi: 10.2202/1547-7355.1399

Signorini, L.F., 2013. *Le economie delle regioni italiane nel tempo della crisi: l'analisi economica territoriale in Banca d'Italia*. [pdf]. Available at: <https://www.bancaditalia.it/pubblicazioni/interventi-direttorio/int-dir-2013/Signorini-291113.pdf> [Accessed 5 February 2019].

Simmie, J. and Martin, R., 2010. The economic resilience of regions: towards an evolutionary approach. *Cambridge journal of regions, economy and society*, [e-journal] 3(1), pp. 27-43. Doi: 10.1093/cjres/rsp029

Swanstrom, T., 2008. *Regional resilience: a critical examination of the ecological framework*. [pdf] Institute of urban and regional development working paper. Available at: <https://www.econstor.eu/bitstream/10419/59401/1/59286166X.pdf> [Accessed 5 February 2019].

Walker, B.H. and Meyers, J.A., 2004. Thresholds in ecological and social ecological systems. A developing database. *Ecological and Society*, 9 (2), art.3.

Walker, B., Hotelling, C.S., Carpenter, S.R. and Kinz, Z.A., 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society*, 9 (2), art.5.

Appendix

Table A1. Variables model description

$\ln(\text{PIL}_{it})$	logarithm of regional GDP (gross domestic product at market prices per capita, concatenated values with reference year 2010)
NI_{it}	net imports (import-export balance) as a percentage of GDP
$STEM_{it}$	graduates in science and technology - percentage of graduates in scientific and technological disciplines per thousand inhabitants aged 20-29
I_{it}	private investment in GDP - private investment as a percentage of GDP
IB_{it}	patent intensity - patents registered at the European Patent Office (EPO) (number per million inhabitants)
ABB_{it}	school dropout rate- early leavers- school leaving of the total number of secondary school enrollments in upper secondary schools in percentage terms
RF_{it}	Financing risk (loan decay rate)
RD_{it}	Incidence of total R&D expenditure on GDP-Total spending on R&D as a percentage of GDP
LQa; LQi, LQc; LQs	Local Quotients in agriculture, industry, construction, services sectors.

Source: ISTAT, 2019