

# The resilience of the regional ecosystems: Healthcare-service organizations, public agents and communities in times of Covid-19

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The aim of this study is to compare regional ecosystems' resilience in terms of their ability to contain the spread of Covid-19. This is carried out through institutional measures as well as through spontaneous community behaviour in order to preserve public health and the institutional actions to strengthen the health-care system in dealing with the pandemic. The discussion is framed through the institutional approach. We develop a two-step method. In the first step, regions have been clustered by considering the kind of response to Covid-19, in terms of formal and informal rules. In the second step a random effect panel regression analysis was performed in order to define the effect of the single response variable to Covid-19 on the resilience index over time. Implications for policy makers are then discussed. The first is that coping with a

regional emergency requires taking into account regional specificities. Strictly imitative models risk being inconsistent with the characteristics of the area, resulting in outputs that are not homogeneous. The second involves social capital, which is crucial to the application of the norms. In regions with high social capital there is a sense of solidarity that presents itself in informal rules aimed at reinforcing the formal rules. However, there is no sense of conformity for the sake of conformance to the standard.

*Keywords:* Resilience, Regional Ecosystems, Formal rules, Informal rules.

## **La resilienza degli ecosistemi regionali: organizzazioni dei servizi sanitari, enti pubblici e comunità in tempi di Covid-19**

*L'obiettivo di questo studio è confrontare la resilienza degli ecosistemi regionali in termini di capacità di contenere la diffusione del Covid-19. Ciò avviene attraverso misure istituzionali e comportamenti spontanei della comunità al fine di preservare la salute pubblica e le azioni istituzionali per rafforzare il sistema sanitario nel gestire la pandemia. La discussione*

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*ne è inquadrata attraverso l'approccio istituzionale. Abbiamo sviluppato un metodo a due fasi. Nella prima fase, le regioni sono state raggruppate considerando il tipo di risposta al Covid-19, in termini di regole formali e informali. Nella seconda fase, è stata eseguita un'analisi di regressione panel a effetti casuali per definire l'effetto della singola variabile di risposta al Covid-19 sull'indice di resilienza nel tempo. Vengono poi discusse le implicazioni per i responsabili delle politiche. La prima è che affrontare un'emergenza regionale richiede la considerazione delle specificità regionali. I modelli strettamente imitativi rischiano di essere incoerenti con le caratteristiche dell'area, producendo risultati non omogenei. La seconda riguarda il capitale sociale, cruciale per l'applicazione delle norme. Nelle regioni con un elevato capitale sociale c'è un senso di solidarietà che si manifesta in regole informali volte a rafforzare le regole formali. Tuttavia, non c'è un senso di conformità per il solo scopo di uniformarsi allo standard.*

*Parole chiave: resilienza, ecosistemi regionali, regole formali, regole informali.*

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## 1. Introduction

The spread of Covid-19 in Italy is sadly known worldwide. Italy was the first European hotspot of the spread of the virus characterized by a dramatic and sudden ability to propagate the entire territory (Troisi, De Simone, Vargas, Franco, 2022). This spread was uniform: depending on the waves affecting Italy, the virus showed a different incidence on a territorial scale, prompting the Italian government to

establish general guidelines for the prevention and treatment of Covid-19, which varied by region.

Regions, therefore, became the main public agent in facing the pandemic on the front-line, consistently both with its own means and the territorial characteristics of pandemic.

The objective of this study is therefore to compare regional responses to Covid-19 in terms of ecosystem resilience, highlighting the capacity to contain the spread of this contagious disease.

Three theoretical arguments frame our discussion.

As first the region is defined as a geographical-administrative space that corresponds to a territorial ecosystem (Host *et al.*, 1996). Institutionally, the Region has the authority to regulate directly on the basis of issues of local importance. From a geographical viewpoint, it contains a range of agents located in a geographical area whose actions are regularly interdependent, sharing mutual objectives. The ecosystem-region is described here as healthcare network, territorial social capital, and government bodies in charge of policymaking (Feldman and Zoller, 2016).

The second argument is about the notion of ecosystem resilience. This is a complex concept because it considers the adaptive capacity to sudden change as being a collective response of all the agents present in the ecosystem while also endowing it with a degree of specificity. Thus, the territorial resilience developed as a result of these conditions is unique to a territory, as its adaptive capacity. Regaining dynamism and charting a new course after a major disruption requires the consideration of both the past and the

present, peculiar to any ecosystem (Troisi and Alfano, 2021).

Finally, the resilience of the ecosystem is explored under the institutional approach (North, 1990; 2005; Guerrero-Cano *et al.*, 2006). According to this viewpoint, the ecosystem is more than just a regional network. Its distinct capabilities are determined by the presence of both formal and informal local institutions. On the one hand, the public agent's efficient regulations direct behaviour patterns with spatial effects ranging from regional to local depending on the type of institution. Informal rules, on the other hand, are equally important rules of the game in geographically defined areas. In fact, they are the result of prior experiences, local customs, and specific knowledge, and they play a role that is sometimes complementary to official rules, and other times explicitly conflicting (De Simone, 2017).

Furthermore, the resilience of the regional ecosystem against Covid-19 has the primary goal of developing health-protection responses based on the two trajectories depending on the complex nature of Covid-19. The first is concerned with the broader protection of public health, which a contagious disease clearly jeopardizes. It allows for the introduction of new behavioural patterns, which results in restrictions on public life. The change in a set of social rules has been largely credited with preventing and controlling the spread of Covid-19 (e.g. Dutta and Fischer, 2021). The regional ecosystem's resilience is primarily based on mandatory regional and local regulatory responses (for example, public measures related to transportation, public spaces, and facilities, as well as a set of controls to regulate

citizens' behaviours). At the same time, the resilience of the regional ecosystem is provided by citizens' spontaneous choices to behave in ways that are appropriate for public health protection.

The second is more focused on the resilience of regional health-care systems in developing the most appropriate responses to Covid-19. The formal institutional aspect is dominant in this case. However, examining the regional decisions on their own health-care systems emphasizes their differences. Among the distinctive capabilities of ecosystems, there is also a different way of establishing rules that are more adapted to their specificity, such as spending capacity, consistency with their health system governance models, and recognition of one's own community (De Simone, 2014). The resilient responses in terms of public health and healthcare are inextricably linked. Changing the rules of behaviour is undoubtedly the most important way to reduce the incidence of a contagious disease and, as a result, to improve the health-care system's response with a consequent tenable reduction of Covid-19 patients.

Thus, we compare local ecosystems by combining public health measures and health care system options in terms of their combined capacity to positively support the regional resilience.

Empirically, we develop a two-step method. In the first step, regions have been clustered according to their kind of response to Covid-19, in terms of formal and informal rules. In the second step a random effect panel regression analysis was performed to define the effect of the single response variable that Covid-19 had on the resilience index, over time.

**Tab. 1** – Regional ecosystem and rules, the conceptual framework

Agents	Aim	Kind of rules	Regional resilience
Region	Preserving public health (ordinances with a set of restrictions).	Formal	Regional containment of <i>Covid-19</i> spread.
Region	Strengthening the health-care system (ordinances about models and operational measures)	Formal	
Municipalities	Preserving public health (integration of the regional ordinances, urban planning).	Formal	
Communities	Spontaneously respecting the provisions.	Informal rules	

The overall findings should assist policymakers in learning from various regional models of resilience by drawing on lessons from the frontlines. This can make significant contributions by examining:

- 1) in terms of formal rules, (i) the key regional model in the emergency management of the healthcare care system (ii) the type of means developed to protect public health, and
- 2) in terms of informal rules (i) the relevance of the social capital in addressing spontaneous community effort for developing resilient responses.

Tab. 1 depicts the conceptual framework of this study.

## 2. Literature insight

### 2.1. The regional ecosystem

The concept of ecosystem includes two aspects. First, no agent can be understood in isolation. They are dynamically coordinated through constant flows of information required to achieve a common goal.

Second, there is usually a centralized coordination model led by a higher level public agent (Laihonen, 2012), but it is not strictly hierarchical; rather, it tends to widen to a series of par-

ticipants whose roles are defined based on the importance of their contribution at any given time.

The regional public agent is critical to ecosystems. It combines regulatory expertise with spending capacity, and as such, it is primarily responsible for defining patterns of behaviour at the regional level, typically in ordinary situations but occasionally in emergency situations too. In Italy a health emergency falls under the jurisdiction of the region because health is entirely devolved to this. At the same time, the regional ecosystem identifies in municipalities a further, albeit minor, regulatory subject, limited to its geographical scope, for some matters affecting municipal economic and social life (Bellavista *et al.*, 2021). The health-care system is critical in health-emergency situations. It functions as a network within a network, with key actors, hospitals, and other healthcare units in constant communication (Troisi *et al.*, 2022).

Finally, the communities have to also be considered since they are directly affected by the measures and can play as active, spontaneous agents, at the same time. They are considered fundamental promoters of development and sustainability for regional ecosys-

tems (Franco and Tracey, 2019) and, as in this instance, resilience.

## 2.2. Ecosystem resilience

A significant number of studies from various social disciplines consider ecosystem resilience as a complex issue due to the number of agents involved and their heterogeneity. In theory, there is widespread agreement that a complex problem cannot be approached in a piecemeal manner. However, studies are frequently focused on single resilience dimensions pertaining to communities, networks, or organizations, neglecting the fact that these dimensions must be interconnected (Weick and Sutcliffe, 2007). Three conditions must be met in order to fully understand the phenomenon of ecosystem resilience:

- 1) The localized nature of the event. It could also be a larger-scale event, but the consequences must vary by territory.
- 2) The presence of both formal and informal local institutions.
- 3) A network of relationships that exists prior to the resilient response is then required. It is difficult to imagine a network built to reduce the impact of an undesirable event on a larger scale without agents ever sharing common spaces of action. In an emergency, the network should not be tested, but rather consolidated.

The territorial resilience that develops as a result of these conditions is thus unique to a territory, as well as its adaptive capacity. Particularly, the local adaptation of shared strategies, culture, heritage, knowledge, and experience are critical elements in

promoting disaster resilience (Elcheroth and Drury, 2020).

The flow of information needed to respond quickly to a crisis via the vector of geographical proximity is the main feature of the ecosystem's resilience. Geographic proximity is well known to facilitate face-to-face interactions and thus the immediate exchange of information. According to Kechidi and Talbot (2010), face-to-face communication can address and solve new problems that none of the participants in isolation would be able to handle. The ecosystem is a potential that, when activated by participant interaction, reproduces a resilient response to the benefit of individual actors and with the added benefit of a multiplier effect for the ecosystem as a whole (Gilly & Torre, 2000).

## 2.3. The institutional approach

Some key arguments are extracted from the institutional theory. The institutional approach focuses on how the existence of social interactions tends to stabilize reality through processes of legitimation and to define constraints on the range of possible actions, reducing the variability and unpredictability of individual behaviour (De Simone, Franco, 2022). The formal norms should efficiently orient the communities' behaviour (Franco, De Simone, 2011). When formal norms work efficiently, informal norms tend to work in a complementary way representing further support. In different circumstances, where formal norms do not work efficiently, informal norms are often in conflict with them (Colombo *et al.*, 2019).

As previously mentioned, the formal rules fulfil a double aim in facing the Covid-19 emergency. They are intend-

ed to protect public health by preventing or limiting contagion and to adapt the health-care system to the needs of crises in order to treat the pandemic.

First, the formal rules are intended as a response to the public health crisis. The rules limit social contact, restrict access to public places, impose obligations to wear masks according to places and times, and thus provide a series of behavioural rules that represent, to varying degrees, restrictions on citizens' freedom (Reina *et al.*, 2021). They mainly fall under the regional jurisdiction, with a different degree of pervasiveness within the framework of general national principles.

These types of rules are integrated with more detailed municipal rules, such as ordinances related to lockdown times, or the type of local police checks to verify compliance with the ordinances, or the type of fine. In addition to these tools, urban planning can play an important role. As is well known, this is a tool that precedes the Covid-19 emergency, but if well developed, it can contribute to the resilience of a regional ecosystem in any emergency. Firstly, the presence of large parks in cities, the balanced distribution of housing in order to avoid, or, at least control densely populated areas, the presence of the necessary facilities and the regulation of transport for each urban area can be considered features associated with citizens' greater well-being during lockdown (Mouratidis and Yiannakou, 2021). At the same time, this kind of urban planning has the side effect of facilitating social distancing. In essence, the plans developed considering the whole urban quality of life as the key factor, are in themselves the

most suitable plans to deal with any type of emergency.

Formal rules are also aimed at the response to the health-care crisis: the regions envision a combination of operational measures and governance models to effectively enhance the health care system. It has been observed that the governance model used to improve health system response can be divided into two main coordination models. The first proposes a hybrid of centralisation and legitimisation: rules for strengthening hospitals and networks are primarily made at the central level, with the assistance of technical figures to gain public consensus. On the other hand, a mix of decentralization and professionalization characterizes "territorial medicine". This strives to strengthen social and health units, as well as home hospitalization, by utilizing medical experts and resources outside of hospitals to reduce the number of hospital admissions (Troisi and Alfano, 2021). Finally, informal rules govern the behaviour of citizens, who are fundamental supporters of the decision to respect rules of behaviour that severely limit personal freedom (Berardo and Lubell, 2019). We could speak of a culture of solidarity, respect, and community protection, and these values make the formal rules imposing restrictive models of behaviour much more acceptable. Our assumption is that formal rules are more widely respected in regions with higher social capital because they are consistent with informal rules. Consequently, Italian regions can differ not only in the regulations they impose but also in the degree to which their regulations are respected (Bentkowska, 2021).

### 3. Data and method

#### 3.1. Data sources

The data were obtained, classified and operationalized as follows:

- 1) data about the resilience index was obtained from daily reports from the Ministry of the Interior;
- 2) in terms of formal rules, regional ordinances were evaluated because they are the primary source of social limitations and hence the key instrument for ensuring public health. Regional ordinances also define the choice between hospital-focused treatment and territorial medicine within the context of the health care system. Both kind of data were taken from the Regions' websites (2.1) Municipal ordinances and urban planning

- 3) as for informal rules we use three proxies: the number of infractions on the social capital; the number of vaccinations on the social capital; the number of downloads of the “Immuni app” on the social capital. Data for these proxies were gathered from ISTAT and Ministry of the Interior websites. We choose 2021 as the base year since emergency response became more extensive (vaccinations, immunological applications, and freedom restrictions) and there was a higher quantity of data than in 2020.

#### 3.2. Variables and methods

The resilience index was calculated by the following formula (Coccia, 2022):

$$r_i = \frac{1}{3} \sum_{j=1}^3 F_{ij} \text{ with } r_j \leq 1; j = 1, \dots, n \text{ regions}$$

where:

- $F_{1j}$  is the daily mortality rate per 100000 inhabitants in a specific region in a given period;
- $F_{2j}$  is the daily spread per 100000 inhabitants in a specific region in a given period;
- $F_{3j}$  is the daily ICU occupancy rate per 100000 inhabitants in a specific region in a given period.

The values  $F_{1j}$ ,  $F_{2j}$ , and  $F_{3j}$  were standardized in the range from zero to one before calculating the resilience index. The index was calculated monthly. In accordance with this study, the resilience index has been utilised on a regional-urban scale in a number of

articles to examine if institutional initiatives affected the Covid-19 trend (e.g., Gong *et al.*, 2020).

Regarding the formal rules variables, regional ordinances have been identified in other studies as the primary regional normative sources for both public health guidelines and health care governance decisions (e.g., Troisi and Alfano, 2021). They have been operationalized in numbers for public health decisions.

In the context of the health care system, the option between hospital-focused therapy and territorial medicine has been operationalized by calculating the proportion of hospitalised patients to the overall number of positive cases. Dividing the average monthly value of

the rate into tertile, in line with Specchia *et al.* (2021), it is possible to identify three approaches: a hospital-centered approach for regions in the first tertile, an integrated approach for regions in the second tertile, and a territory medicine-based approach for regions in the third tertile.

Local ordinances have been considered as formal rules of an integrative nature, and largely for public order objectives in earlier publications that focus on cities as pandemic transmission hotspots (Nunes Silva, 2022). They have been quantified and aggregated on a regional basis.

Urban planning is considered to be a major institutional action that can orient peoples' behaviour in minimizing Covid-19's viral effects for two reasons. Firstly, the presence of large parks in cities, the balanced distribution of dwellings for avoiding or managing high population density, and the regulation of mobility for each metropolitan region are associated with inhabitants' improved well-being during lockdown (Mouratidis and Yiannakou, 2021). Secondly, this type of urban planning also facilitates social distancing, minimising imbalances that can lead to non-compliance in poor areas. Plans developed with urban quality of life in mind are better suited to handling any emergency (Mouratidis, 2021). In Italy, urban regulation has imposed a succession of limits on construction and maintenance over the previous two decades (e.g. DL 380/2001). Modern plans have more restrictions than those dating back to before national regulations. The variable was operationalized as the percentage of municipalities in a region with an urban plan adopted after 2016.

Social capital is commonly used as a proxy for positive informal rules such as solidarity, civic awareness, and respect for others. Some research on Covid-19 demonstrates that formal regulations are more likely to be applied where they are consistent and hence reinforced by informal standards (Bentkowska, 2021). The way informal norms, with an emphasis on social capital, have been operationalized is a unique feature of this work.

We calculated a ratio between social capital and the degree of compliance with three types of legislation adopted during the study period:

- 1) Socially obligatory constraints.
- 2) Vaccination against Covid-19 (recommended but not essential).
- 3) Downloading the "Immuni" application if desired.

This link enables us to comprehend why particular formal regulations are adhered to, as an informal rule of solidarity and respect for community members who may support it, or a rule is respected regardless of the circumstance.

This is crucial because we believe that the formal norms established during the pandemic are both new and emergency-specific, and as such, they may produce diverse results even in the face of a uniform social capital indicator. The variables have been operationalized as the number of infractions on the social capital; the number of vaccinations on the social capital; the number of downloads of the "Immuni app" on the social capital. Social capital index was given by ISTAT (2019). The measurement is based on three funda-



mental pillars: 1) generalized trust, 2) the strength of associative relationships, and 3) civic and political participation reflected in a variety of ways. Individual assessments are used to appraise everyone.

We used a two-step method for the analysis. In the first step, regions were clustered considering the kind of response to Covid-19, in terms of formal and informal rules. The clusters enable the grouping of regional responses into homogeneous models while emphasizing two conditions:

- 1) from the standpoint of the ecosystem, they combine multiple agents and responses;
- 2) different models demonstrate that response is not paradigmatic, but rather varies by place;
- 3) it allows for a comparison between the resilience index for each cluster, as well as for single regions.

In the second step a random effect panel regression analysis was performed. The model defines the effect of the single response variable that Covid-19 had on the resilience index, over time.

Using cluster analysis, similar responses to Covid-19 in different regions can be detected. Based on the observed values of the features of each response, similar observations are grouped into a number of clusters. In line with previous studies (e.g. Troisi and Alfano, 2022 a,b), similarity denotes that certain groups share relatively similar features with some and are significantly different from others.

Using R-project, a hierarchical cluster analysis was performed. We used Ward's method for calculating Euclidean Distance from the numerous clus-

tering criteria present in the software's source code. The minimum variance criterion of Ward (1963) is based on sum-of-squared errors (SSE): two elements/clusters create a new cluster when the within-cluster sum-of-squared error is minimal (Everitt *et al.*, 2011).

Panel regressions analyze the relationship between the independent variable (i.e., the resilience index) with a set of explanatory variables over time. Generally, a panel model can be written as follows:

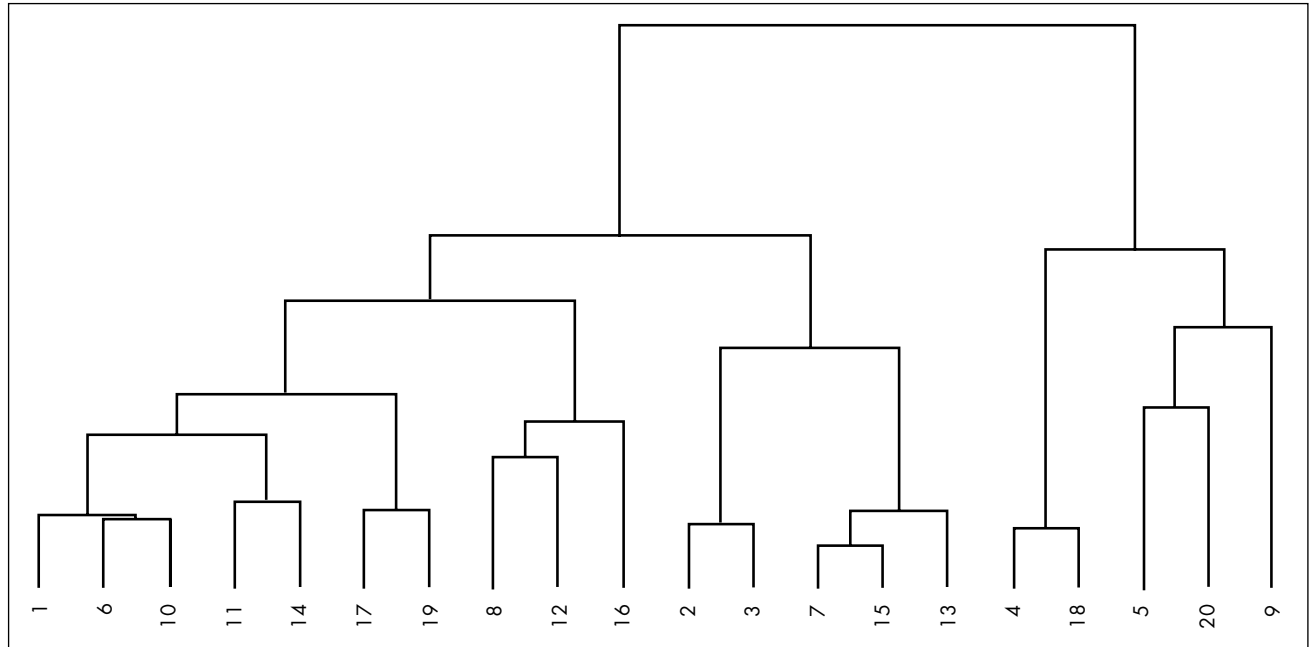
$$Y_{it} = \beta_{it} x_{it} + u$$

Where  $y_{it}$  is the dependent variable considered,  $\beta_{it}$  is the vector of parameters to be estimated,  $x_{it}$  is the vector of explanatory variables considered and  $u$  is the error term. The explanatory variables used in this analysis are the response variables previously described. In addition, a lag variable of the resilience index was added to the model in order to account for regional characteristics, not explicitly considered in the model, which may affect the resilience index (Wooldridge, 2010).

#### 4. Findings

Using a dendrogram analysis (Fig. 1) and the maximum silhouette coefficient (i.e., 0.36), we determined three groups with the most distinct boundaries.

Tab. 2 shows the summary statistics of the characteristics of the regional ecosystem response for the three clusters. The decisions taken by the regions in the first Cluster are characterized by an intermediate number of ordinances (in comparison to the other clusters) and a low reliance on



**Fig. 1**  
Dendrogram

territorial medicine. The number of ordinances at the local level is also intermediate, as are the plans. The social capital/infraction ratio is the most virtuous. In this cluster, manda-

tory regulations are more strictly enforced, however, optional requirements such as vaccination and “Immuni” app downloads related to social capital provide a lower out-

**Tab. 2** – Clusters summary statistics and resilience index

Variables	Cluster 1	Cluster 2	Cluster 3	Total sample
Regional ordinances	12.63 (3.21)	6.93 (0.97)	18.25 (2.82)	12.61 (4.33)
Territorial medicine	1.83 (0.52)	2.36 (0.37)	2.33 (0.42)	2.09 (0.51)
Local ordinances	11.49 (3.39)	6.48 (1.35)	16.03 (5.58)	11.38 (5.40)
Planning	20.98 (9.20)	9.85 (7.54)	25.71 (19.64)	19.38 (13.0)
Infractions on social capital	374.94 (249.25)	528.67 (245.41)	1440.14 (620.47)	679.67 (574.64)
Vaccinations on social capital	2213.06 (1889.76)	6283.80 (3710.63)	9790.63 (3918.60)	5125.14 (4285.75)
Immuni app downloads on social capital	4668.88 (4800.83)	5797.15 (5085.32)	14974.48 (7986.46)	7527.35 (7033.69)
Resilience index	0.41 (0.09)	0.33 (0.11)	0.49 (0.13)	0.41 (0.17)
Number of regions	10	5	5	20

come than in other clusters. Cluster 2 has the lowest percentages for regional and local ordinances, as well as municipal planning. However, it turned out to be the strongest in territorial medicine. It falls somewhat in the middle of the clusters for all three variables in terms of informal rules. Cluster 3 has the highest employment rates for all variables, with the exception of territorial medicine, which has a little lower rate than cluster 2 values.

Tab. 2 displays the average resilience index per cluster, indicating response homogeneity (similar formal rules as well as a similar degree of enforcement of informal rules). It is evident that the average resilience index is higher for cluster three, where there is a stronger usage of formal rules alongside more up-to-date plans and where

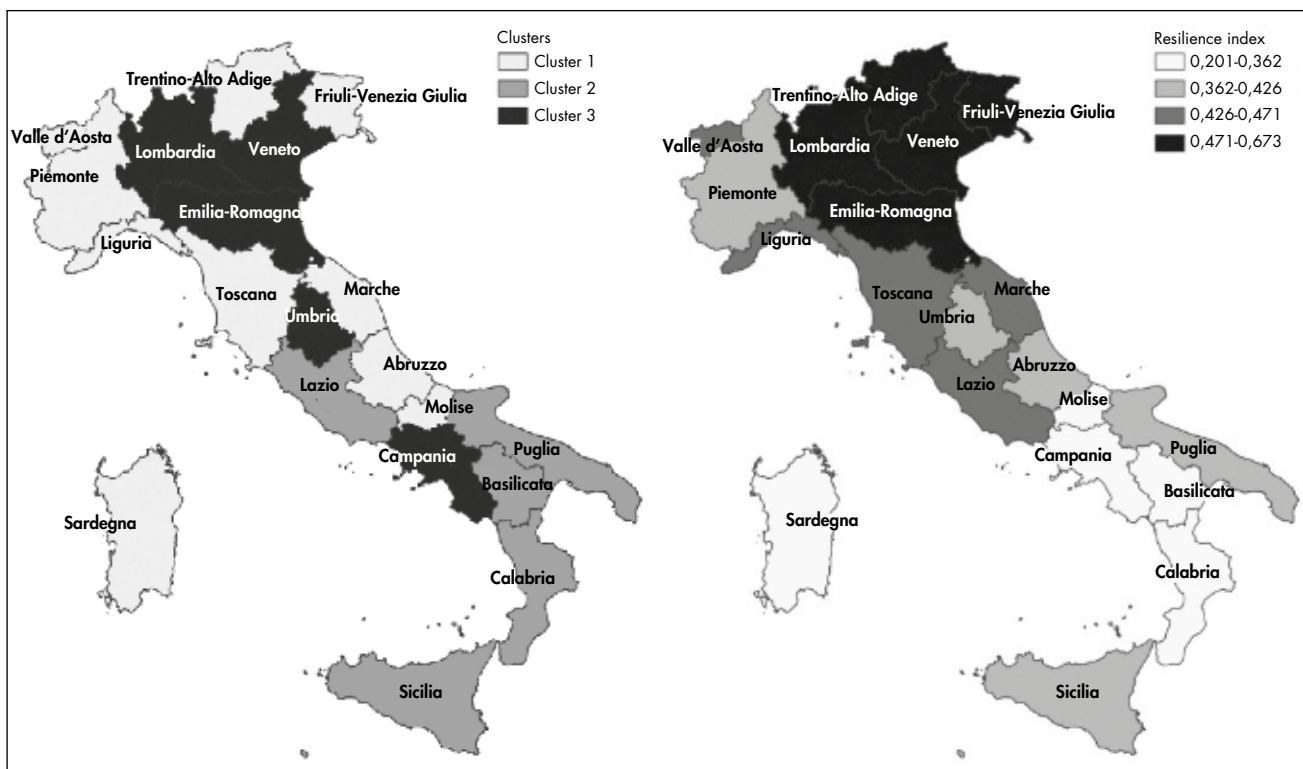
informal norms provide a greater percentage of support.

However, the distinctiveness of regional ecosystems counterbalances homogeneous cluster models. In fact, Fig. 2 illustrates how the uniqueness of a region's ecosystem can result in varying degrees of resilience within the same cluster. Despite employing a comparable response model to that of Lombardy, the resilience index of Campania is quite low. In contrast, Lazio, which is included in cluster 2 with the lowest level of resilience, gets a medium-high resilience value.

Tab. 3 shows the random effect panel regression results and the diagnostic tests for the model.

Regarding the formal rules variables, regional ordinances are positively and significantly related to the resilience

**Fig. 2**  
 Clusters and Resilience index



**Tab. 3** – Panel regression results

Variables	Coefficients (Standard Error)
Intercept	3.82e-02 (2.62e-02)
Regional ordinances	2.56e-03 (8.69e-04)**
Territorial medicine	2.33e-02 (8.10e-03)**
Local ordinances	2.75e-04 (6.91e-04)
Planning	1.29e-03 (5.40e-04)**
Infractions on social capital	-1.24e-05 (4.16e-06)**
Vaccinations on social capital	3.30e-06 (1.17e-06)**
Immuni app downloads on social capital	1.01e-06 (1.11e-06)
Lag(resilience index)	5.95e-01 (4.78e-02)***
R-squared	0.67
Chi-squared	428.19 on 8 DF. p-value: < 2.22e-16
Significance code: *** p<0.01; ** p<0.01; * p<0.05	

index over time (2.56e-03,  $p < 0.01$ ). This shows that the resilience index is higher in regions that adopted a greater number of restrictions compared to regions that adopted fewer restrictions. The relationship between territorial medicine and the resilience index is positive (2.33e-02,  $p < 0.01$ ). Thus, the index is greater in locations where a territorial approach to hospitalizations is chosen.

Regarding the local informal rules variables, urban planning is significant and positively related to the regional resilience index (1.29e-03,  $p < 0.01$ ). The results confirm that an updated urban plan is useful to increase the resilience to the Covid-19. Local ordinances were not significant.

As for the informal rules, infractions on social capital in negatively related to resilience (-1.24e-05,  $p < 0.01$ ). According to this result, the resilience index is greater in regions where the number of violations committed on the social capital is lower, as compared to regions where the number of viola-

tions committed on social capital is higher. Vaccinations, on the other hand, were found to have a significant and positive relationship with Covid-19's resilience (3.30e-06,  $p < 0.01$ ). Therefore, communities that have a higher number of vaccinated individuals on social capital and are, as a result, closer to having herd immunity are distinguished by a higher value of the resilience over time. The download of the Immuni app was not found to be significantly related to resilience. Lastly, the control variable considering the lagged value of the resilience index is positively related (5.95e-01,  $p < 0.001$ ).

## 5. Discussion and conclusions

This study attempts to provide a more comprehensive knowledge of the resilience of regional ecosystems by addressing two major challenges. The first, more general, question is whether ecosystems have different models of resilience but equal capacity to face an emergency, based on the the-

oretical assumption that ecosystems' environments have their own specificities, with models that are not necessarily imitable, or whether the resilience of regional ecosystems tends to favour a prototypical solution, which introduces characteristics of replicable efficacy independent of place.

The cluster analysis reveals two potential responses to this question. Although agents in the ecosystems are identical, their responses vary along two lines. First, we created three clustered groups, which resulted in three response models as opposed to one. Regarding formal rules, the distinction between clusters is quantitative, based on their high, middle, and low use, as well as their usage of territorial medicine. As far as informal rules are concerned, the distinction between the groups is the degree to which they adhere to formal restrictions. This suggests that the responses of the regions were not significantly imitative, but rather that the response models were sufficiently diverse. Second, despite the fact that Cluster 3 has a higher resilience index due to a greater use of formal and informal rules, there are specific regions that counterbalance the overall result, highlighting the importance of specificity, with negative results being produced in a positive cluster and vice versa.

Substantially, the findings suggest that an approach based on many formal rules to protect public health, supported by social capital compliance with the rules, is the most resilient model. This model of health governance strikes a balance between the use of hospitalizations and territorial medicine. What emerges is that the specificity of areas and ecosystems is vital,

and so any model of resilience must be tailored regionally, while taking local demands into consideration.

The second question is identifying the variables that affect the resilience index.

In regard to the examination of the variables and their effect on the resilience index, it is essential to note that regional ordinances, as anticipated, have a positive effect on the index, whereas this is not confirmed for local ordinances, which appear to be redundant and are not effectively complementary to regional ordinances. Instead, territorial medicine serves as a vital complement to hospital medicine and consequently has a positive effect on the index, most likely due to its ability to reduce the number of patients requiring hospitalisation and the number of interactions between persons. In both ordinary and emergency scenarios, the enhanced planning proves to be a valuable tool for balancing people, spaces, and locations.

A crucial characteristic of informal norms becomes apparent: these work when they support mandatory or strongly recommended standards, but not when they support optional provisions. Therefore, the more obligatory restrictions are accorded a higher value of solidarity than the optional ones.

Finally, the most significant implications of our analysis concern policymakers. The first is that coping with a regional emergency requires taking into account regional specificities. Strictly imitative models risk being inappropriate for the characteristics of the area, resulting in outputs that are not homogeneous. Thus, it is not erroneous to conceive of common response models, as long as they are

integrated at the local level with what the emergency prioritises and are consistent with the varying local resources available. The second involves social capital, which is crucial to the application of the norms. In regions with high social capital,

there is a sense of solidarity that presents itself in informal rules aimed at reinforcing the formal rules. However, there is no sense of conformity for the sake of conformance to the standard. This explains the Immuni app and its failure.

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