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The diffusion of COVID-19 in Italy: An exploratory economic geographical analysis in the first pandemic wave

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1. *Introduction*

In April 2020, more than 2.000.000 people were already tested positive to the new coronavirus (COVID-19) disease worldwide (Il Sole 24 ore – Center for Systems Science and Engineering, John Hopkins University). Originally discovered in Wuhan (i.e. the capital of the Hubei province, in China) in December 2019, the virus has afterwards spread globally and it is currently classified as a coronavirus pandemic by the World Health Organization (2020). It is believed that in most cases the spread between people occurs through the respiratory droplets emitted by an infected individual through coughing or sneezing which, subsequently, are inhaled by a healthy person who is nearby. It is possible to get infected even after touching surfaces or objects where the virus is present, then bringing your hands towards your mouth or towards your nose or eyes.

The COVID-19 has hit the European countries hardly and led to a serious health emergency in Italy, i.e. the country with the highest number of cases (behind Spain) and overall deaths in Europe in the first pandemic wave (March-April 2020). Lombardy (North Italy) is the Italian region (NUTS 2 level) that has been more severely affected by the COVID-19. Besides, after the first patient was tested positive in the Lombard province of Lodi (NUTS 3 level) in mid-February, the contagion has diffused quickly throughout the rest of the region and in most of the northern areas of the country.

Overall, in the first wave the top five affected regions in Italy (i.e. Lombardy, Emilia-Romagna, Piedmont, Veneto and Tuscany) account for 75% of the total confirmed cases in Italy (i.e. 105,602 out of 142,510) (Il Sole 24 ore – Center for Systems Science and Engineering, John Hopkins University). At

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a glance, these regions and the other considerably affected ones (e.g. Liguria, Lazio and Marche) largely overlap the most dynamic and competitive regional economies of the country.

Based on these considerations, I tackled the following research question in the present paper: which are the most relevant socioeconomic and environmental features that have potentially and dangerously fostered the COVID-19 contagion in the most affected Italian provinces (NUTS 3 level)?

The empirical analysis is based on an economic geographical approach and, in particular, I focused on the agglomeration (e.g. population density, share of employed persons), level of connectivity (Relationship Intensity Index - RII) and level of richness (GDP per capita) of the Italian provinces and their association with the COVID-19 diffusion.

Scholars in the field of economic geography tend to highlight the positive effects of agglomeration economies and connectedness, although they may similarly lead to negative externalities. Among other things, spatial clustering may be related to increasing costs of production, poorer standards of living, higher land and housing prices, traffic congestion, poverty, crime and pollution (see also Murgante *et alii*, 2020). In this regard, high population density may facilitate the spread of contagion and negatively affect the more industrialized areas of the country (Tarwater, Martin, 2001; Ascani *et alii*, 2020). Similarly, places showing a high degree of connectivity within them and with other geographical areas may be exposed to higher risks. Finally, some researchers argue that pollution may have an impact on the COVID-19 contagion rate showed by regions and countries (Murgante *et alii*, 2020; Casti, Adobati, 2020; Setti *et alii*, 2020). The intention is to test these hypotheses by looking at the Italian provinces, where the diffusion of COVID-19 cases seem to follow precisely these patterns, thus confirming what a first glance would suggest (i.e. the highest number of cases observed in the more industrialized, competitive and well-connected northern areas of Italy).

For this purpose, my empirical analysis refers to the sub-regional areas of the country (i.e. provinces, NUTS 3 level) and relies on principal component analysis (PCA), cluster analysis and Pearsons's correlation for testing the association between some potentially relevant socio-economic and other environmental indicators (PM10, mean temperature) and the total number of COVID-19 reported cases.

This paper is organized as follows. The next session presents a brief review of the literature on the topic, also taking into account the contribution of the economic geography to the spatial spread of the pandemic. In the third section, the methodology and the indicators used in the study are presented. Afterwards, the main features of spatial spread of Covid-19 in Italy, its geographical distribution across the country, the results of the PCA and Pearson's correlation are presented in the fourth section. Finally, the discussion is drawn in the fifth section.

2. *Theoretical framework: an overview*

There are several factors that can lead to the spread of a virus such as COVID-19 within a specific geographical region and on the planetary scale. Although it is still early to have a complete interpretative picture from a scientific point of view, various scientists belonging to different disciplines have ventured into the study of this phenomenon. Geography also felt the need to make a contribution to the study of what is not only a health phenomenon but also a social phenomenon and as such it can, and must be studied by this discipline in its various social, economic, environmental and spatial components.

To understand and interpret social phenomena it is essential to know where they occur, i.e. to keep in mind their spatiality (Maggioli, 2015), to better understand how and why these phenomena happened. Even more important, however, is to move from a purely spatial to a territorial one, which takes due account of the relationship between man and his territory (Casti, Adobati, 2020).

Economic geographers tend to emphasize how spatial concentration of individuals, i.e. what we define as high population density, can be related to higher production costs, lower living standards, higher level of housing crowding (because of higher land and housing prices), traffic congestion, poverty, crime and pollution, all elements facilitating the transmission of the virus (Tarwater, Martin, 2001; Ascani *et alii*, 2020), since they lead to an increase in contacts between individuals (i.e. face to face contacts) and transgressive behaviors (e.g. non-respect for social distancing). Thus, even the spatial concentration of economic activities, which can lead to agglomeration economies, can show their «dark side» (negative externalities) favoring a faster transmission of the virus due to the dense localized interactions (e.g. contacts with customers and colleagues) and the greater contacts due to extra-regional connections (Ascani *et alii*, 2020), or due to working methods that mainly require interpersonal contacts, not allowing the possibility of working remotely (Montenovo *et alii*, 2020).

Over the years, geographic studies have attempted to explain the spread and effects of various infectious diseases. Wen *et alii* (2012) studied the spreading effects of Dengue fever, highlighting how commuter workers are an important vehicle for transmitting the virus from their home to their workplace. In summary, their study underlines how despite the fact that the elderly and the nannies could be the source of infectious outbreaks at a local level, however, commuters, transporting the virus to geographically distant areas, are the main carriers of the epidemic on a large scale.

Turning our attention to the pandemic from Covid-19, the first studies at European level focused on the macro-region first and most affected by the pandemic: Northern Italy.

A first study, carried out in this macro-region, analyzes the spread of the contagion in the province of Bergamo and more generally in Lombardy, the territory with the greatest presence of economic activities and also the one most affected by the pandemic (Casti, Adobati, 2020). Although underlining that in Lombardy the most important outbreaks occurred initially in the peri-urban areas (Boterman, 2020; Levy, 2020), subsequently the infection affected the larger urban areas. The results of this study are in line with mine, even if it is a work in progress.

Conticini *et alii* (2020) study the correlation between the high level of severe acute respiratory syndrome CoronaVirus 2 (SARS-CoV-2 – COVID-19) lethality and air pollution in Northern Italy, in particular in two regions of Lombardy and Emilia Romagna. The study shows that one of the causes of the spread and lethal effects of the virus are due to the high levels of some pollutants (PM2.5, PM 10, O3, SO2, NO2) which entail, for the population established in that particular region, the development of chronic respiratory diseases and an increased susceptibility to infectious agents. For these scholars, the high level of pollution in northern Italy could be considered an additional cofactor of the high level of lethality recorded in the Lombardy area.

In the next sections I will try to highlight which are the main socioeconomic and environmental factors that have triggered the COVID-19 diffusion in Italian provinces.

3. *Materials and methods*

3.1 *Methods* – I used PCA, cluster analysis and Pearson's correlation for determining a possible correlation between the diffusion of COVID-19 and a set of socioeconomic and environmental variables. The research design comprises three steps. First, I conducted the PCA for creating a taxonomy of the Italian provinces (NUTS 3 level) based on the various indicators adopted (except the number of COVID-19 reported cases).

Second, I carried out a cluster analysis for determining which provinces make up the components I identified through PCA.

Third, I conducted a correlation analysis for assessing the existence of a potential correlation between the COVID-19 and the factor scores (i.e. the components I identified through PCA) to which the Italian provinces showing given characteristics belong.

3.2 *Specification of the methodological approach* – The adoption of PCA allowed me to classify and describe the spatial models that characterize given regions based on a set of socioeconomic and environmental variables. PCA is an abstract approach that can be used to detect patterns of similar development.

Various researchers (e.g. Taylor, Walker, 2001; Growe, 2016) stress how one of the major advantages in adopting this method is the possibility to reduce and identify the number of indicators useful for the purpose of a given research (i.e. in our case study, I reduced the number of components from 8, corresponding to each variable adopted, to 3). PCA is particularly useful in determining the existence of latent variables that are not included in the initial data set. Each component identifies a new latent (uncorrelated) variable, containing as much information as possible on a given phenomenon, based on the correlation between a subset of those variables that have been originally used to conduct the empirical analysis. Three main components were identified using the Kaiser method (Del Colle, Esposito, 2000). These components help explain 66% of the variance observed in the data set used to test the model.

Subsequently, a hierarchical cluster analysis (based on the nearest neighbour method; see, among others, Calignano, Hassink, 2016, and Calignano, Vaaland, 2018) allowed me to determine which provinces belong to each component I identified.

Finally, I conducted a correlation analysis for assessing the existence of a correlation between the diffusion of COVID-19 and the three components observed in my model.

3.3 *Data and indicators* – As mentioned above, I used PCA, cluster analysis and Pearson's correlation for determining the existence of an association between some critical selected socioeconomic or environmental indicators and the diffusion of the COVID-19 in the Italian provinces.

In particular, I first calculated the share of cases in each Italian province on the overall number of reported cases in Italy (CASES). I stopped data collection on 10 April 2020 because of methodological reasons. This decision depended on the peculiarities of the first wave, which took the national (government, Ministry of Health) and local (regional authorities) institutions in charge of public health by surprise, thus leading to delays in the implementation of ad hoc actions. This element allowed me to capture the actual impact of the pandemic on the socioeconomic and demograhic structures before the policy measures adopted by the various national and public institutions and their related effects on the various local contexts, which could be observed only after the time period considered in the present study. The data on the diffusion of the COVID-19 are provided by the Italian Ministry of Health and originally collected by the Italian Civil Protection.

Moreover, I used various indicators based on datasets provided by the Italian National Statistics Institute (ISTAT), Ministry of Agricultural Food and Forestry Policies (MIPAAF) and Eurostat. Almost all the data I used refer to NUTS3 level, while the data relating to Connectivity and PM10 levels are at the LMA and municipal scale respectively. These data are approximated at the provincial level. In particular, I used the following socioeconomic indicators (Table 1) for carrying out the PCA:

- Population density calculated as the total number of inhabitants per square kilometre (DENSITY). This indicator refers to the year 2019. Population density is a factor that can potentially determine a higher degree of contagion, given that the frequency of social interactions is larger within more crowded space units (Tarwater and Martin, 2001). Social contacts represent an important driver in disease transmission, particularly in the case of respiratory infectious agents (Ascani *et alii*, 2020);
- Number of employed persons in each province on the total number of employed persons at the national level in percentage (EMPL). This indicator was measured for the year 2017. It is an indicator of spatial concentration of employees in a province. Frequent social contacts at the workplace and a considerable number of various eco-

nomic activities (e.g. retail and commercial activities) may lead to a higher number of contacts, thus representing a potential risk in terms of disease contagion;

- Tourism intensity, i.e. the ratio of nights spent at tourist accommodation establishments relative to the total permanent resident population of the area. Data about this indicator refers to the year 2018 (TOURISM). Tourist flows may similarly represent a potential risk factor in terms of disease transmission.
- Gross domestic product per capita at the provincial level is an indicator which reflects the local demand and captures the level of economic opportunities in a region (GDP per capita);
- Connections within the Labour Market Areas (LMAs) were measured through the so-called Relationship Intensity Index (RII; ISTAT, 2015). This indicator (Lipizzi, 2014) is defined as the percentage of flows within an LMA that connects different municipalities (net of the employed who reside and work within the individual municipalities) out of the total flows within the LMA (CONNECTIVITY). This indicator is measured at LMA level. These flows are a potential driver of disease transmission given the higher frequency of social interactions within a certain area (See Section 3.3).
- Mean temperature, which is the average of the maximum and minimum temperatures in the February 2019 - March 2019 period (MEAN TEMPERATURE). I included this indicator since the COVID-19 is similar to flu virus in terms of spread of contagion; i.e. its diffusion is higher throughout the winter, when the temperatures are lower (Becchetti *et alii*, 2020; Notari 2020).
- Particulates are considered the most harmful form of air pollution (Murgante *et alii*, 2020; Setti *et alii*, 2020) due to their ability to penetrate deep into the lungs and blood streams unfiltered, causing heart attacks, respiratory disease, and premature death. This indicator is measured at the municipal level (See Section 3.3).
- The indicator measuring population at the provincial level includes both labour workforce or economically active population (i.e. employed, self-employed and unemployed persons), and part of the economically inactive population (i.e. pre-school children, school children, students) (AGE POP 0-64). This age group is likely to be more prone to contract the infection due to higher exposure to face to face interactions (e.g. work and school activities, leisure, etc.).

Tab. 1 – Indicators and Source.

INDICATORS	SOURCE	OBSERVATION
Covid-19 cases	Italian Ministry of Health – Civil Protection 2020	Provincial
Population Density	Istat 2019	Provincial
Number of employed	Istat 2017	Provincial

Tourism rate	Istat 2018	Provincial
GDP per capita	Our elaboration on Eurostat Data 2017	Provincial
Connectivity	Istat 2011	LMA
Mean Temperature	Mipaaf 2019	Provincial
Population Age 0-64	Our elaboration on Istat Data 2019	Provincial
PM10	Istat 2018	Municipality

Source: our elaboration.

4. *Results*

4.1 *The diffusion of the Covid-19 in Italy* – The study considers the reported cases of COVID-19 in Italy until 10 April 2020. More specifically, I calculated the share of reported cases in each Italian province on the overall number of cases in Italy (CASES).

The map below shows the different distribution of contagion cases in the Italian provinces (Figure 1). Most of them are concentrated in the northern part of the country, in particular in regions such as Lombardy, Piedmont, Emilia Romagna and Veneto.

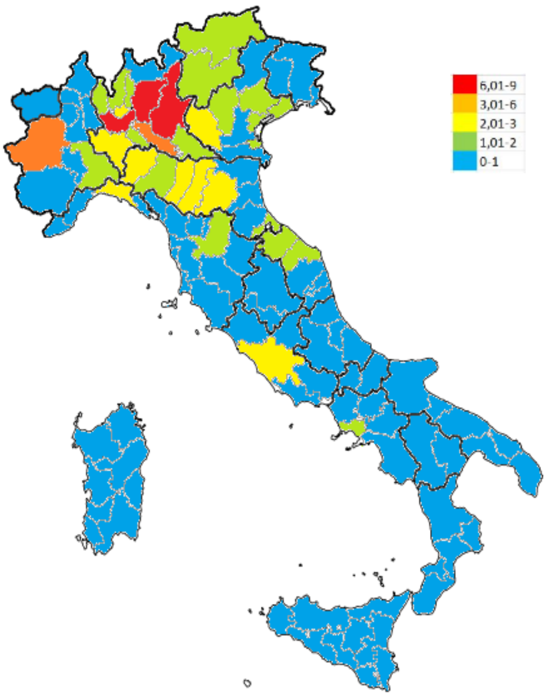

Fig. 1 – The diffusion of Covid-19.

Source: Author's elaboration on data Italian Ministry of Health – Civil Protection 2020.

Lombardy has the largest spread of virus in the provinces of Milan, Bergamo and Brescia. The virus also shows average diffusion values in the provinces of Veneto, Trentino Alto Adige and Emilia Romagna. Piedmont is characterized by a peculiar situation since, although most of its provinces show low levels of contagion, the province of Turin shows medium-high values. Other areas affected by the spread of the virus are the metropolitan areas of Rome (Lazio – Centre Italy), Naples (Campania – South Italy), Florence (Tuscany – Centre Italy) and the provinces of Pesaro-Urbino and Ancona in the Marche region (Centre Italy).

4.2 *Principal Component Analysis* – After briefly describing the geographical areas that are mainly affected by the COVID-19 in Italy, I conducted PCA for creating a taxonomy of the Italian provinces based on their socio-economic and environmental characteristics. The model includes all the variables described above (see Section 3.2), with the only exception of the variable CASES (i.e. the variable referring to contagion), and is able to explain 66% of the total variance. The adoption of the Kaiser method and varimax rotation allowed me to identify three components (eigenvalue > 1). All the variables that show a correlation higher than 0.4 with latent variables were included in each component (Table 2).

The first component, that I named «Dense and polluted provinces», includes all the provinces that show a high population density, high employment rate, high percentage of active population and a higher degree of particulates in the air. This component explains more than 30% of the total variance observed in the dataset. I named the second component «Dynamic, connected and rich provinces» since it includes the provinces that show a high GDP per capita, high level of connectivity, i.e. connections within the respective LMAs and low temperatures. This second component explains near the 22% of the variance. Finally, I identified a third component, which explains a small of portion of the total variance (near the 13%), that I named «Open and rich provinces». The provinces showing the major tourism flows and a high GDP per capita make up the third component.

Tab. 2 – Principal Component Analysis.

PRINCIPAL COMPONENT ANALYSIS (PCA)					
Dense and polluted provinces		Dynamic, connected and rich provinces		Open and rich provinces	
Density	+	GDP per capita	+	Tourism	+
Employees	+	PM10	+	GDP per capita	+
PM10	+	Connectivity	+		
Age Pop 0-64	+	Mean Temperature	-		

Source: our elaboration.

4.3 *Cluster analysis: Which provinces make up each component?* – Having determined three main components based on the socioeconomic and environmental indicators adopted, I conducted a cluster analysis with the aim of identifying which provinces actually make up each component. More specifically, I adopted hierarchical cluster analysis (nearest neighbour method) and used only the variables that showed a correlation higher than 0.4 with the latent variables in the PCA I carried out. This method allowed me to find a clear pattern regarding Component 1 and Component 2 (see Annex A).

Figure 2a shows the geographical location of the provinces that make up the Component 1 («Dense and polluted provinces»). At a first glance, it can be noticed that the most of the provinces are mainly concentrated in Northern Italy. These geographical areas coincide almost entirely with the provinces that show percentage values of the contagion from Covid-19 higher than 1% (see Figure 1). In particular, most affected provinces are included in the Component 1: Milan, Brescia, Bergamo and Cremona in Lombardy and Turin in Piedmont, with values above 3 percentage points. Other provinces are added with values ranging from 1 to 3 percent located in the administrative regions (NUTS 2 level) of Lombardy, Veneto, Emilia Romagna and Piedmont and the provinces of Pesaro-Urbino and metropolitan area of Rome (Centre Italy). The first component describes the provinces characterized by high population density, high percentage of the number of employees, high levels of PM10 air pollution and a very young and active population, aged between 0 and 64 years. These characteristics, as highlighted by the PCA, show a strong association with the spread of the infection in those specific geographic areas (see Section 4.4).

Moreover, Figure 2b shows the geographical patterns related to the Component 2 («Dynamic, connected and rich provinces»), which similarly highlights groups with a high number of northern provinces and preliminary reveals a clear association with the COVID-19 contagion rate. As specified above, the Component 2 refers to the Italian provinces showing high GDP per capita, high degree of connectivity, high air pollution (i.e. levels of PM10) and low temperatures. The provinces that make up Component 2 seem to largely overlap the ones comprised in the Component 1 in the northern part of the country, while the southern regions are not included (this might depend on the considerably lower GDP per capita and, more generally, lower regional socioeconomic dynamism). The most important northern provinces making up Component 2 are Milan, Brescia, Bergamo and Cremona in Lombardy and Turin in Piedmont, together with many other provinces in Lombardy, Veneto, Emilia Romagna and Piedmont (see Fig. 1).

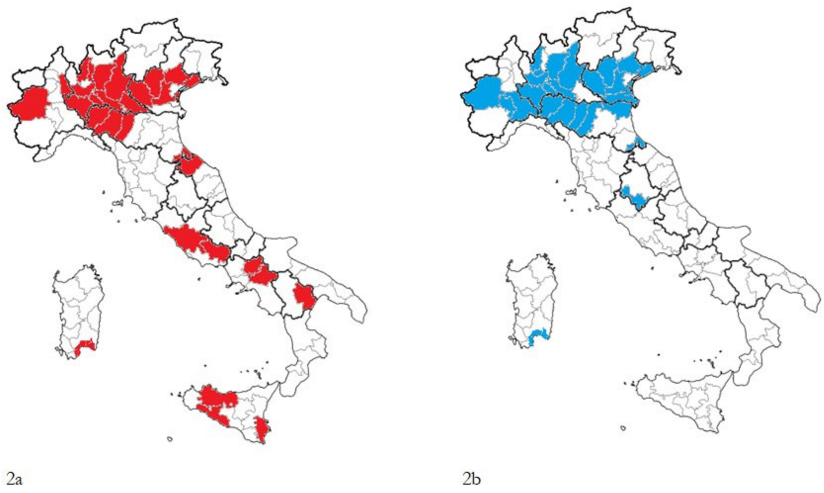

Fig. 2a-2b – The first and second component.
Source: Author's elaboration.

4.4 *Correlation between factor scores and COVID-19 contagion* – The results of the PCA and cluster analysis reported in Sections 4.2 and 4.3 reveal the existence of some clear geographical patterns based on the socioeconomic and environmental indicators I adopted. The aim is now to understand whether there is a correlation between the three components I identified and the reported cases of COVID-19 in the various Italian provinces. I used Pearson's correlation for this purpose (see Annex B). Statistical analysis clearly shows that the provinces I defined «Dense and Polluted» (Component 1) and the ones I classified as «Dynamic, Connected and Rich» (Component 2) are correlated with the degree of COVID-19 contagion observed in the Italian provinces. In particular, there is a stronger association between «Dense and Polluted» provinces and reported cases (.596), even though the correlation showed by the «Dynamic, Connected and Rich» provinces is similarly moderately high (.415). These two components highlight how the co-presence of certain factors can favor the spread of the pandemic in particular geographical regions. In fact, territorial contexts characterized by high population density, with a young population and of working age, intense social and work relationships (face to face contacts) and high connectivity, present a more intense spread of the epidemic. These contexts also show low temperatures during the winter periods and high levels of PM10 pollution, which often lead to respiratory problems among the population, increase the risk of contracting infectious diseases such as COVID-19. Conversely, I found a weak positive, but not statistically significant, association between «Open and Rich» (Component 3) provinces and numbers of reported cases in the targeted Italian provinces. It is worth remembering here the lack of a clear geographical pattern for the Component 3 (see Section 4.3).

5. *Discussion*

The exploratory analysis contained in this paper aims at seeking the existence of an association between the number of infected people and some critical socioeconomic and environmental indicators in the context of the Italian provinces (NUTS 3 level) in the first pandemic wave. In economic geography, it is widely acknowledged that a critical mass of firms and people in regional or sub-regional areas is beneficial for the local or regional economy, although this may have a negative impact in the case of a pandemic event such as the COVID-19.

In fact, as emerged from this study, the geographical area most affected by the spread of the coronavirus is represented by the northern part of the Italian peninsula (called Po valley), an area that is historically characterized by an intense presence of economic activities and a high spatial concentration of inhabitants. From the morphological point of view, the Po valley is an alluvial plain between two mountain ranges (Alps and Apennines) that produce a concave shape in which air currents struggle to enter and give rise to a continental type climate (Casti, Adobati, 2020). The Po valley includes parts of the regions of Piedmont, Lombardy, Emilia-Romagna, Veneto and Friuli-Venezia Giulia, most of the regions hit hardest by the pandemic. Due to its poor ventilation, industrialization and high population density, the problem of air pollution has intensified for several decades, which not only affects metropolitan areas or industrial areas but is distributed and affects the entire macro-region (Casti, Adobati, 2020). In fact, the two main components associated with the spread of Covid-19 highlight the presence of the factors mentioned above: the first component shows how the provinces are characterized by spatial concentration of inhabitants, young and of working age, of economic activities, which also involve more intense interpersonal relationships, and high levels of pollution to highlight a greater spread and intensity of the contagion; the second component, on the other hand, identifies those areas with a high level of per capita income, high levels of pollution, low temperatures in winter and very intense relationships between different areas (within the respective LMA). This last aspect, underlines how the movements of the inhabitants deriving from commuting both for study and for work take on a not secondary importance in the spread of the infection, as highlighted in other studies concerning the analysis of the spread of infectious diseases (Wen *et alii*, 2012).

All these factors distinguish, for the Italian context, the regions where the spread of the virus has manifested itself most intensely, bringing to its knees not only the health system at the local level but also the entire industrial and commercial system of the most dynamic and rich regions of the country.

This study is in line with the results of other studies carried out both in Italy and in other countries (see among others Rodriguez-Pose and Burlina, 2020). Unlike other authors, however, who are more likely to focus their attention on purely economic aspects and specialization (Ascani *et alii*, 2020) or mainly on environmental and health aspects (Murgante *et alii*, 2020; Casti, Adobati, 2020) or population density (Boterman, 2020), I try to outline the main socio-economic and environmental features of the province most hit by the epidemic, trying to draw a picture, albeit not exhaustive, of the co-factors that may have contributed to the spread of the virus.

Despite the descriptive nature of this work, I can deduce some policy implications. In the first place, the work allows to highlight the link between the incidence of COVID-19 and the socio-economic and environmental characteristics of some Italian provinces, in particular those located in the Po valley. This aspect is important to policy makers, especially at the local level, in defining targeted measures in the event of any outbreak. Moreover, social distancing measures and reinforced containment controls could be prolonged in areas susceptible to more frequent transmissions (Ascani *et alii*, 2020). Since these areas also represent the economic heart of the national economy, strong public financial support for these locations should be incorporated into the containment measures. Secondly, the recognition that the geography of COVID-19 contagion does not follow a random pattern, but is associated with specific socio-economic and environmental profiles, can be a crucial element for the involvement of politics at different territorial scales (regional, national, supranational), in the design of targeted support tools. In this regard, addressing the challenges of COVID-19 and, more generally, those related to public health or future natural shocks require effective government choices, ability to build consensus and stronger informal institutions. Only a combination of these elements might prevent the damages suffered by the European regions, which have been hit very hard by the current pandemic (Rodriguez-Pose, Burlina, 2020). Finally, in the presence of a relationship between COVID-19 cases and certain socio-economic and environmental structures at the local level, future research lines should take into account not only the effects of the impact of COVID-19 on local economic systems, but also the possibility of studying the phenomenon at lower spatial scales (eg LMAs).

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The diffusion of COVID-19 in Italy: An exploratory economic geographical analysis in the first pandemic wave

The coronavirus disease 2019 affected Italy before and more severely than other European countries. The exploratory analysis contained in this paper, based on various statistical techniques, aims at seeking the existence of an association between the number of infected people and some critical socioeconomic and environmental indicators in the context of the Italian provinces (NUTS 3) during the first pandemic wave. In economic geography, it is widely acknowledged that a critical mass of firms and people in regional or sub-regional areas is beneficial for the local economy, although this may have a negative impact in the case of a pandemic event such as the COVID-19. The empirical analysis enabled us to distinguish three main components, to which correspond three distinct typologies of Italian provinces: «Dense and Polluted», «Dynamic, Connected and Rich» and «Open and Rich». As expected, the first two components show a moderately strong and statistically significant correlation with the registered cases in the Italian provinces, thus revealing a possible association between the spread of the contagion and the densest, most dynamic and competitive Italian regions.

La diffusione del COVID-19 in Italia: un'analisi geografico-economica esplorativa durante la prima ondata pandemica

L'infezione da coronavirus ha colpito l'Italia prima e più duramente di altri paesi europei. L'analisi esplorativa contenuta in questo lavoro, basata su diverse tecniche statistiche, mira a ricercare l'esistenza di un'associazione tra il numero di persone infette e alcuni principali indicatori socioeconomici e ambientali nel contesto delle province italiane (NUTS 3) durante la prima ondata pandemica. Nella geografia economica, è ampiamente riconosciuto che la concentrazione di imprese e persone in aree regionali o subregionali è vantaggiosa per l'economia locale, sebbene questo possa avere un impatto negativo nel caso di un evento pandemico come il COVID-19. L'analisi empirica ha permesso di distinguere tre componenti principali, a cui corrispondono tre distinte tipologie di province italiane: «Dense and Polluted», «Dynamic, Connected and Rich» e «Open and Rich». Come atteso, le prime due componenti mostrano una correlazione moderatamente forte e statisticamente significativa con i casi registrati nelle province italiane, rivelando così una possibile associazione tra la diffusione del contagio e le regioni italiane più densamente popolate, dinamiche e competitive.

La diffusion du COVID-19 en Italie: Une analyse géographique économique exploratoire dans la première vague pandémique

La maladie à coronavirus 2019 a touché l'Italie avant et plus sévèrement que les autres pays européens. L'analyse exploratoire contenue dans cet article, basée sur diverses techniques statistiques, vise à rechercher l'existence d'une association entre le nombre de personnes infectées et certains indicateurs socio-économiques et environnementaux dans le contexte des provinces italiennes (NUTS 3) lors de la première vague pandémique. En géographie économique, il est largement reconnu que la concen-

tration d'entreprises et de personnes dans les zones régionales ou sous-régionales est bénéfique pour l'économie locale, bien que cela puisse avoir un impact négatif dans le cas d'un événement pandémique tel que le COVID-19. L'analyse empirique nous a permis de distinguer trois composantes principales, auxquelles correspondent trois typologies distinctes de provinces italiennes : «Dense and Polluted», «Dynamic, Connected and Rich» et «Open and Rich». Comme prévu, les deux premières composantes montrent une corrélation modérément forte et statistiquement significative avec les cas enregistrés dans les provinces italiennes, révélant ainsi une possible association entre la propagation de la contagion et les régions italiennes les plus denses, les plus dynamiques et les plus compétitives.

ANNEX A

Total Variance Explained

Component	Initil Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,506	31,319	31,319	2,506	31,319	31,319	2,072	25,898	25,898
2	1,752	21,900	53,219	1,752	21,900	53,219	1,914	23,925	49,822
3	1,027	12,841	66,061	1,027	12,841	66,061	1,299	16,238	66,061
4	,827	10,336	76,397						
5	,685	8,557	84,954						
6	,561	7,007	91,960						
7	,356	4,448	96,408						
8	,287	3,592	100,000						

	Component		
	1	**2**	**3**
P Z(DENSITY)	,821	,024	-,005
P Z(EMPLOYEES)	,823	,167	,103
P Z(TOURISM)	-,044	-,076	,901
P Z(GDP per capita)	,161	,614	,611
P Z(PM10)	,579	,416	,037
P Z(AGE POP 0-64)	,524	-,265	-,294
P Z(CONNECTIVITY)	,259	,744	-,089
P Z(MEAN TEMPERATURE)	,126	-,840	-,086

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

ANNEX B

Correlation

		P Z(CASI_ PERCENT)	**REGR factor score 1 for analysis 3**	**REGR factor score 2 for analysis 3**	**REGR factor score 3 for analysis 3**
P Z(CASI_ PERCENT)	Pearson's correlation	1	,596**	,415**	,107
	Sign (two-sided)		,000	,000	,275
	N	107	107	107	107