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The role of transport accessibility within the spread of the Coronavirus pandemic in Italy

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ARTICLE INFO

Keywords:
SARS-CoV-2
Covid-19
Pandemic
Mobility
Transportation
Accessibility
Safety

ABSTRACT

The Covid-19 pandemic has caused an unprecedented global crisis and led to a huge number of deaths, economic hardship and the disruption of everyday life. Measures to restrict accessibility adopted by many countries were a swift yet effective response to contain the spread of the virus. Within this topic, this paper aims to support policies and decision makers in defining the most appropriate strategies to manage the Covid-19 crisis. Precisely the correlation between positive Covid-19 cases and transport accessibility of an area was investigated through a multiple linear regression model. Estimation results show that transport accessibility was the variable that better explained the number of Covid-19 infections (about 40% in weight), meaning that the greater is the accessibility of a certain geographical area, the easier the virus reaches its population. Furthermore, other context variables were also significant, i.e. socio-economic, territorial and pollutant variables. Estimated findings show that accessibility, which is often used to measure the wealth of an area, becomes its worst enemy during a pandemic, providing to be the main vehicle of contagion among its citizens. These original results allow the definition of possible policies and/or best practices to better manage mobility restrictions. The quantitative estimates performed show that a possible and probably more sustainable policy for containing social interactions could be to apply lockdowns in proportion to the transport accessibility of the areas concerned, in the sense that the higher the accessibility, the tighter should be the mobility restriction policies adopted.

1. Introduction

At the end of 2019, in the city of Wuhan (Hubei, China) the first worldwide outbreak of Coronavirus pathogen, also known as Covid-19, was observed (Chinazzi et al., 2020). By 20 January 2020, there had been 282 confirmed cases of Covid-19 from four countries including China (278 cases), Thailand (2 cases), Japan (1 case) and the Republic of Korea (1 case) (World Health Organization, 2020). In March 2020, the World Health Organization (WHO) declared that the Coronavirus epidemic was a global pandemic (Liu et al., 2020). In March 2020, the World Health Organization (WHO) declared that the Coronavirus epidemic was a global pandemic (Liu et al., 2020). The outbreak of Covid-19 had swept across China rapidly and spread to 117 countries outside China (60% of all countries worldwide) by 12 March 2020. On this date, the WHO (2020) announced a total of 125,260 confirmed cases globally, 80,981 of which were confirmed in China and 44,279 outside, with 4613 deaths overall (3.68%). On July 2020, a total of 13.5 million cases were confirmed globally, with about 600,000 deaths estimated worldwide.

Public health priorities are to hold clinical trials on potential drugs for Covid-19, and to develop an efficient and safe vaccine. This is why most of the scientific research has concerned the medical aspects of Covid-19 such as infectivity, virulence, origin, susceptible population, transmission, preparedness, pathogenesis, and clinical severity of the Covid-19 infection (Guo et al., 2020; Rothan and Byrareddy, 2020; Somily and BaHammam, 2020; Surveillances, 2020). Human-to-human transmission of the virus occurs by contact with droplets and small particles produced when those infected cough or sneeze. This leads to the isolation of patients who are then administered different treatments. Therefore, there are still no specific antiviral drugs or vaccine against Covid-19 infection for potential human therapy. Another key factor in the spread of Covid-19 is so-called social distancing which became necessary during the pandemic outbreak to reduce contagion. The distance to be kept between individuals is estimated to be about 1.5 m (World Health Organization, 2020), and is considered effective because most saliva droplets fall and reach the ground and/or evaporate before reaching 1.5 m.

While researchers have focused mainly on health issues to combat
the virus, other main topics discussed widely in the literature seek to correlate the number of cases and deaths of Coronavirus to both meteorological and air quality (pollution) variables. With respect to meteorological parameters, several studies have observed that temperature and relative humidity positively influence the spread of Covid-19 (Shi et al., 2020; Tosepu et al., 2020; Wu et al., 2020b; Zhu and Xie, 2020).

For example, in Hubei (China) Qi et al. (2020) observed that every 1 °C increase in the average temperature with relative humidity in the range from 67% to 85%, led to a 36% to 57% reduction in confirmed Covid-19 cases. In addition, the authors also concluded that every 1% increase in relative humidity led to an 11% to 22% reduction in daily confirmed cases with average temperatures in the range from 5.0 °C to 8.2 °C.

With respect to air quality impacts upon the spread of Covid-19, some recent research has shown that people living with long-term exposure to air pollution are more likely to become infected by Coronavirus. For example, Conticini et al. (2020) concluded that prolonged exposure to air pollution may help a viral agent, such as Covid-19, to be more lethal among the population living in such phenomena. At the same time, Pluchino et al. (2020) identified the PM10 concentration as a factor of the vulnerability component of the risk in Covid-19 analysis.

Further, in a study conducted by Wu et al. (2020a) of the Harvard T.H. Chan School of Public Health in Boston it was shown that an increase of 1 μg/m³ in PM2.5 brings about an 8% increase in the Covid-19 death rate.

Since transmission of the virus occurs through interaction among people, the transportation system rather than pollution and/or environmental conditions, is plausibly the main cause of the spread of the Coronavirus (e.g. Cartenì et al., 2020). This because crowding, that is the main causes of the human to human transmission of the virus, occurs where activities are carried out (e.g. in the work place, in schools and leisure areas). Such activities can be reached via the transport system which allows trips between different areas (e.g. home to work trips; home to leisure trips). From a theoretical perspective, the concept which combines the need to carry out an activity with the possibility (reachability) of doing it is accessibility (or transport accessibility). Accessibility is commonly defined as the possibility to reach activities (active accessibility) in a geographical area, or the ease of reaching activities by potential citizens (passive accessibility) (e.g. Ben-Akiva and Lerman, 1979; Cascetta, 2009; Geurs and Van Wee, 2004; Pirie, 1979). Accessibility is the topic that mainly underlines the dependence between the activities system and the transportation system. This is the reason why urban lockdown, together with mobility restrictions, has been the common practice to contain the spread of the Coronavirus pandemic worldwide. For example, according to Fang et al. (2020) without the lockdown in Wuhan (China), the total number of Coronavirus positive cases would have increased by about 65% in the Chinese cities outside Hubei province, and by more than 52% in the 16 other cities within Hubei. Countries impacted by the pandemic are using expedients such as mobility and/or travel restrictions, minimum distance, and quarantine (Müller et al., 2020) to slow down the virus. In March 2020 Italy enacted similar restrictions on mobility, showing just a few weeks later a reduction in the number of new infections. Furthermore, transport accessibility can increase the probability of contagion both directly, for example through trips made via public transport where social distancing cannot be guaranteed, or indirectly (e.g. through private car trips) because such trips are a measure of the number of activities performed in a certain area, activities that are based on citizen interactions (e.g. studying, shopping, cinema, sports) and which favour the spread of the Coronavirus.

To the authors’ knowledge, an issue which has not yet been investigated in the literature is the correlation between Covid-19 positive cases and the transport accessibility of an area. In aiming to bridge this gap, the paper investigates the conjecture according to which the total number of Coronavirus cases in an area is directly related to its transport accessibility (reachability), in the sense that the higher an area’s accessibility, the easier it is reached by the virus. The application case study concerns about the spread of Covid-19 in Italy. The proposed case study was suitable for the purposes of the paper because Italy was the first European country to experience mass contagion of the virus. Furthermore, as the spread of the Coronavirus was contained in May 2020, it is now possible to analyse the impacts produced thanks partly to the great availability of contagion data and transport accessibility measures observed at a national scale and for a long time period.

To this end, quantitative estimation was performed from the transportation and safety point of view: the hypothesis according to which the total number of Covid-19 cases is directly related to transport accessibility, in addition to other context factors, was investigated. Estimates were made through a multiple linear regression model linking the total number of certified Coronavirus cases to socio-economic, territorial, pollution, and transport accessibility variables.

The paper is organized as follows. Section 2 discusses the spread of the Covid-19 pandemic in Italy; Section 3 reports the data collection and model formulation; Section 4 describes and discusses the results. Finally, our conclusions are reported in Section 5.

2. Spread of the COVID-19 pandemic in Italy

In Italy, the first health crisis due to the COVID-19 outbreak started in Codogno near Milan (Lombardy) on 18 February 2020. The pandemic spread in northern Italy so rapidly that only five days after the outbreak (25 February), a total of 322 infected cases with nine deaths (3% of the total) were detected, with 314 (97.5%) in the North, most in the regions of Lombardy, Veneto and Emilia Romagna, six (1.9%) in central Italy and two (0.6%) infected cases in the South (see Fig. 1).

Before the national lockdown on 9 March, mobility habits had remained almost unchanged. Furthermore, the contagion had already spread almost homogeneously in all the regions already before any accessibility restriction was introduced. Despite the contagion spreading to all regions, the numbers in terms of total cases were amplified in some more than in other regions, as is qualitatively observable from Fig. 2.

The virus continued to grow in terms of new daily cases, peaking on 21 March 2020 (Fig. 1) with more than 4000 cases/day (and a cumulative total of 53,099 cases and 4679 deaths). Subsequently, mobility (accessibility) restrictions started to be effective and the spread of Covid-19 gradually decreased to a safer value. This led to a new phase being started (Phase 2), with fewer mobility limitations. On 3 May 2020, a total of 210,717 cases with 27,368 deaths had been reached nationwide: 168,648 infected (80%) in the North, 24,085 (11%) in central Italy and 17,984 (9%) in the South. On 15 July 2020 the total number of positive cases nationally exceeded 240,000, with about 35,000 deaths.

3. Data collection and model formulation

As stated above, the aim of the paper was to investigate the incidence of transport accessibility within the spread of Covid-19 in Italy. Estimates were made through a provincial (zonal) aggregation level (see the provincial boundaries in Fig. 2) following the classification of territorial units for statistics NUTS 3 of the EU (2020). Overall, the data considered for the estimates were:

- daily reports on new Coronavirus new cases from 21 February to 5 May 2020, sourced from the Italian Ministry of Health (2020);
- the Italian national census data for the year 2019, from ISTAT (2020);
- particulate matter (PM) measurements performed in 2019 by the Italian Regional Environmental Protection Agency (ARPA, 2020);
- the daily level of rail service characteristics (e.g. travel time; train frequency) from February to May 2020, from the two rail transport operators in Italy (Trenitalia, 2020; NTV, 2020);
- an ad-hoc survey carried out in five main rail stations at national level, from October to November 2019, collecting the main mobility
habits of rail passengers (e.g. origin/destination; fare; rail service; age, gender, trip purpose).

Model estimation was performed through a multiple linear regression model by linking the total number of Covid-19 cases in Italy to socio-economic, territorial and transport accessibility variables. The choice of using this kind of model was that the multiple linear regression tool allows the impacts of one group of variables to be separated from the others, or, in other words, the effects of a specific variable to be quantified (e.g. transport accessibility, which is the aim of the paper), other things being equal.

The total provincial positive cases of Coronavirus provided by the Italian Ministry of Health (2020), were considered as dependent variables, while several independent variables were tested at provincial scale among which: socio-economic variables (e.g. population, residents’ density, percentage of elderly residents, number of employees, number of firms); territorial measurements (e.g. kilometers of coastline, square kilometers of urban areas); environmental indices (e.g. pollutant emissions; particulate matter average concentrations); health care measures (e.g. number of Coronavirus tests/day; false negative/positive test results to Covid-19); transportation variables (e.g. car/rail transport accessibility; average car/rail travel time; average number of daily trips).

Several model specifications and independent variables were significant and the best model formulation with respect to the validation indices (R-Squared and t-value, see the results in Table 2) is:

\[
COVID_{19,p} = \beta_1 \cdot POP_p + \beta_2 \cdot POPdensity_p + \beta_3 \cdot South_p + \beta_4 \cdot PM_p + \beta_5 \cdot ACC_p + \text{Constant} 
\]  

(1)

where

\( COVID_{19,p} \) is the dependent variable equal to the total number of Coronavirus positive cases detected in the \( p \)-th province over the
Accessibility can be quantified through synthetic measures based on transportation level of service and/or land-use indicators suitable for considering the relationships between transport and activity systems. Within this classification, there is a copious state of the art concluding that isochrones, cumulative-opportunity and gravity-type measures are the most commonly used zonal-based (aggregate) accessibility indicators (this is the case of this paper) (e.g. Chen et al., 2011; Geurs and Van Wee, 2004; González-González and Nogués, 2019; Guzman et al., 2017; Halden, 2002; Hou and Li, 2011; Odoki et al., 2001; Recker et al., 2001), while utility-based models, space–time measures and perceived opportunities models are generally implemented for individual and disaggregate user-based accessibility estimation (e.g. Cascetta et al., 2016; Handy and Niemeier, 1997; Kwan, 1998).

For the aim of this paper, an active rail-based gravity-type accessibility measure (\(ACＣ_p\)) was estimated to quantify (zonal) provincial accessibility in Italy. Gravity-type models are characterized by an attraction variable (\(Att_d\)) related to the number of activities (e.g. number of employees and/or firms) available at the destination province \(d\) and an impedance function measuring the spatial separation (transportation level of service measures; e.g. distance, travel time) between the origin province \(p\) and the destination province \(d\). In many applications the availability and/or the perception of an activity (opportunity) is not linearly proportional to the transportation attributes, and it mainly follows a “distance decay” trend. The most common non-linear functions proposed in the literature for quantifying the distance decay effect are the \textit{Inverse power function} and the \textit{Negative exponential formulation} (e.g. Cheng and Bertolini, 2013; Hooper, 2015; Kwan, 1998; Martinez and Viegas, 2013). Starting from these considerations, different attraction attributes (\(Att_d\)) and transportation variables (\(T_{pd}\)) jointly with different distance decay specifications were tested according to the following formulation:

\[
ACＣ_p = \sum_{d=1}^{N} Att_d \cdot f(T_{pd}) \tag{2}
\]

where

\(N\) is the number of provinces considered in the study area, which are the 105 administrative provinces in Italy on the mainland and on the island of Sicily, excluding those of Sardinia island not considered due to lack of territorial continuity (source: EU, 2020);

\(Att_d\) is the number of opportunities available in province \(d\), i.e. the total number of employees in industry, service and trade. This attraction measure comprises those that produced the best results in terms of a validation test (RMSE and MAE in Table 1), while other variables were also tested (e.g. total number of firms in different economic sectors) and not reported for brevity;

\(f(T_{pd})\) is the impedance function, measuring the spatial separation between the origin province \(p\) and the destination province \(d\); precisely, two impedance functions, namely \textit{Inverse power} and \textit{Negative exponential} were formulated as follows:

\[
\text{inverse power} : f(T_{pd}) = T_{pd}^{-\alpha} \tag{3}
\]

\[
\text{negative exponential} : f(T_{pd}) = \exp\left(-\gamma T_{pd}\right) \tag{4}
\]

\(T_{pd}\) is the transportation level of service attribute, i.e. the average rail travel time [hours] between the \(pd\) pair. The decision to estimate an accessibility measure the rail transport impedance function, instead of considering, for example, road (car) transport accessibility, was made for two main reasons: i) the Italian rail network is comparable with the highway network at national scale in terms of extension, morphology and capillarity. The railway lines mainly extend alongside the highways, and hence rail and road accessibility are comparable (in terms of relative differences between their provincial measurements, which is what needed in this research); ii) for the rail transport mode, there were much more widespread data available at a national scale, which was therefore better suited to the research aim.

\(\alpha \text{ and } \gamma\) are the model’s parameters.

The model in equation (2) was calibrated starting from the results of a rail mobility habits survey used to estimate the Italian rail origin–destination (\(pd\)) observed percentage distribution, where the generic element, \(p_{b\text{mod}}\), represents the percentage of rail trips between the \(pd\) pair, with \(\sum_{pd} p_{b\text{mod}} = 1\).

Parameters \(\alpha \text{ and } \gamma\) were estimated by minimizing the sum of the square differences between the \(pd\) percentage distribution observed in the sample (\(p_{b\text{obs}}\)) and those predicted by the models (\(p_{b\text{mod}}\)):

\[
p_{b\text{mod}} = \frac{\sum_{pd} Att_d \cdot f(T_{pd})}{\sum_{pd} \sum_{ii} Att_{dii} \cdot f(T_{dii})} \tag{5}
\]

Parameter estimation was carried out through the application of a constrained gradient projection algorithm (with \(\alpha \text{ and } \gamma \geq 0\) consistent with the model’s formulations (3) and (4)). Furthermore, since the convexity of the objective function was not proved, the optimization procedure was applied repeatedly from different starting points directly exploring the admissibility domain with a step forward of 0.1 within the interval [0,3], in accordance with the literature reporting estimates of these coefficients strictly lower than 3 (e.g. Cascetta et al., 2016; Kwan, 1998), and confirmed from the estimation results reported in Table 1.

### 4. Results and discussion

For the estimation of the Covid-19 multiple regression model (1) a time period was considered spannings from the first observed Covid-19 cases on 21 February 2020 to the lowest point of the infection curve (Fig. 1) on 20 April 2020 (60 consecutive days).

Other time periods were also tested and not reported for brevity because they failed to produce significant differences in estimation results.

The active rail-based gravity-type accessibility model (\(ACＣ_p\)) in equation (2) was calibrated starting from the results of a rail mobility habits survey. Specifically, between October and November 2019 a Computer Assisted Web Interviewing (CAWI) survey was carried out in

### Table 1

Active rail-based accessibility model (2): parameters’ estimation results.

| Parameters | Inverse power | Negative exponential |
|------------|---------------|----------------------|
|            | Est. RMSE MAE | Est. RMSE MAE        |
| \(\alpha\) | 0.961 0.055 0.038 | 0.913 0.056 0.040    |
| \(\gamma\) | 0.444         | 0.272                |
ten rail stations at national scale (from northern to southern Italy), namely Turin, Milan, Venice, Florence, Bologna, Rome, Bari, Naples, Reggio Calabria and Palermo. The interviewees (aged > 18 years old) were waiting for a train for an extra province trip (national mobility habit), and comprised those travelling from 7:30 am to 6:00 pm across Italy (e.g. origin in cities of the panel destination everywhere in Italy, and vice versa), considering both workdays and holidays, weighting different days according to the average number of passengers/day measured. The information collected dealt with socio-economic characteristics (e.g. age, gender, education level) and mobility habits (e.g. destination, ticket type; trip purposes). More than 4200 rail passengers were interviewed, randomly selected and stratified according to the city population census data. The main results of the survey showed that the average Italian rail traveler is comparable with those of the national population census data. Thus estimation results can be considered as representative of the Italian population. Specifically, 51% of the respondents were female and 82% were >65 years old. As regards travel behavior characteristics, the results of the surveys showed that 31% of the trips were for business purposes, 25% for commuting, only 10% were for tourism and 34% for other purposes.

The survey results were used to estimate the Italian rail origin–destination (pd) observed percentage distribution (popstpd) model in equation (5). In order to estimate the best rail transport accessibility indicator, formulations of the two impedance functions, Inverse power and the Negative exponential (equations (3) and (4)), were compared. Root-Mean-Square Error (RMSE) and the Mean Absolute Error (MAE) were the goodness of fit indicators estimated from which it emerges that the best model formulation is the Inverse power, even if the Negative exponential formulation also provides comparable RMSE and MAE estimations (Table 1).

Estimation results of the Covid-19 multiple regression model in equation (1) are reported in Table 2. As observed, all the parameters are statistically significant (90–95% significance) and with the expected sign, with an Adj. R-Squared (R-Squared) equal to 0.549 (0.571).

With respect to socio-economic variables, the population variable (POP) was significant meaning that the larger the number of residents in an area, the higher is the probability of contagion. Furthermore, the significance of also the population density variable (POPDensity) means that areas with greater population densities have a higher probability of contagion because of the increase in social activities with overcrowding, being less able to guarantee social distancing.

Among territorial variables, a South variable was significant and negatively correlated with the Covid-19 cases, meaning that regions in southern Italy, characterized by warmer weather and the presence of many kilometres of coastline, in addition to an observed 30% higher average temperature, contributed to contain the Coronavirus contagion. This result is consistent with those observed in other findings which concluded that temperature and relative humidity are negatively correlated to Coronavirus positive cases and deaths (e.g. Qi et al., 2020; Shi et al., 2020; Toșepu et al., 2020; Wu et al., 2020b).

Furthermore, a particulate matter environmental variable (PM) was also estimated, measuring the number of days on which the national daily limit was exceeded. This variable on a provincial scale explains, as observed in other case studies (e.g. Conticini et al., 2020; Pluchino et al., 2020; Wu et al., 2020a), the direct correlation between the number of Coronavirus positive cases and average pollution in the area.

To the authors’ knowledge, an issue which has not yet been investigated in the literature is the correlation between the number of Covid-19 cases and the transport accessibility of an area. Estimation results (Table 2) show that transport accessibility is the variable (ACC) that best explained the number of coronavirus infections, measuring the circumstance investigated in this research that the number of certified cases of Covid-19 is directly related to accessibility, an indirect measure of the extent and quality of the social interactions which can take place thanks to the transportation system. This direct correlation is also qualitatively observable from Fig. 2 through which it may be seen that the distribution of the total cases of Covid-19 within the Italian provinces (left side of Fig. 2) closely reproduce the estimated rail-based transport accessibility (right side of Fig. 2).

Finally, a constant variable was also significant, accounting for all the attributes not otherwise included (explained) in the model.

To better quantify and compare the impacts that each variable accounts for with respect to the others, the average weight of the estimated attributes in counting (from a statistical point of view) the total cases of Covid-19 was also quantified. Precisely, the weight \( W_i \) of the i-th variable was estimated through a sort of weighted average of the coefficient with respect to the attributes in the dataset as follow:

\[
W_i = \frac{\sum p_i \cdot |X_{ij}|}{\sum \sum p_j \cdot |X_{ij}|}
\]

where

- \( p_i \) is the i-th coefficient;
- \( X_{ij} \) is the i-th variable (attributes) relative to the j-th element (record) of the dataset;
- \( \sum_j \) is the sum over the whole dataset;
- \( \sum_k \) is the sum over all the coefficients (parameters).

As reported in Table 3, rail-based transport accessibility was the variable that best explained the number of Covid-19 infections (39.7% in weight), followed by population (11.5%). Territorial and pollutant

| Table 3 Average weight of model variables. |
|-------------------------------------------|
| **MODEL VARIABLE** | **% WEIGHT** |
| population | 11.5% |
| population density | 2.1% |
| south | 2.4% |
| PM pollutant | 6.9% |
| rail-based transport accessibility | 39.7% |
| constant | 37.6% |
| Total | 100.0% |

As reported in Table 3, rail-based transport accessibility was the variable that best explained the number of Covid-19 infections (39.7% in weight), followed by population (11.5%).
variables weighed up to 9.3% (2.4% for the South variable and 6.9% for PM pollutant) in explaining statistically the new cases of contagion. By contrast, population density accounted only for 2.1%. Finally, the non-explained variables (e.g. context effects, individual behavior) that contributed to explain the phenomena.

5. Conclusions

The Covid-19 pandemic ushered in an unprecedented global crisis and led to a huge number of deaths, vast economic loss and major disruption of daily activities. Accessibility restriction measures adopted by many countries constituted a swift and effective response to contain the spread of the virus. In this context, policy makers and practice are still moving in uncharted waters and in this period the role of research in defining robust policies and best practice is more important than ever. In this context, safety science is a key element that could help establish short, medium and long term policies to reduce the spread of the virus whilst minimizing the negative economic and social impacts of the pandemic.

Against this background, the aim of this research was to support policies and decision makers in defining the most appropriate strategies for managing the Covid-19 crisis with respect to both transportation and safety perspectives. The correlation between the Covid-19 positive cases and the transport accessibility of a specific area was investigated. Estimation results show that (rail-based) transport accessibility was the variable that best explained (in statistical terms) the number of Covid-19 infections (about 40% in weight), meaning that the greater the accessibility of an area, the easier the virus reaches its population. Furthermore, other context variables were also significant in explaining the number of Covid-19 positive cases, i.e. socio economic variables (population and population density – about 14% in weight), territorial and pollutant variables (south dummy variable and PM pollutant – more than 2% and about 7% in weight respectively).

This result contrasts with all the good practices of transportation and territorial planning which, in periods of non-health-emergency, aim to increase transport accessibility to boost the attractiveness and economy of a region. On the other hand, in a pandemic, accessibility, which often measures the wealth of an area, becomes its worst enemy, proving to be the main vehicle of contagion and allowing the spread of the virus among the citizens concerned.

The findings of this research are original and, if confirmed in other case studies, would lend support to the efforts of decision and policy makers to improve the safety and security of citizens throughout the phases of the Covid-19 pandemic. In particular, the results of this research will allow the definition of possible policies and/or best practices to better implement mobility restriction measures (e.g. lockdown) which, as observed worldwide, was the most effective action for the containment of Covid-19, ensuring social distancing effectively. The quantitative estimates performed show that unlike the common practice of an indiscriminate across-the-board lockdown for all areas of the country/region/city, a possible and probably more sustainable policy for containing social interactions (with the same effectiveness) could be to apply lockdowns proportionally to the transport accessibility of the areas concerned, in the sense that the greater the accessibility, the tighter must be the restrictive policies adopted (e.g. more days of closure to road traffic, greater reduction in public transport services). By contrast, the case study analyzed showed that the areas of Italy with low and very low railway accessibility had few total cases of Coronavirus, other things being equal. For such areas a less severe lockdown period than that of others (e.g. the first Italian outbreak in Codogno near Milan Lombardy) could well have obtained the same overall effectiveness whilst limiting social unease and economic hardship.

Acknowledgment

The research was also carried out within the activities of funding program VALERE: VANviteLl pér la RicEra; SEND research project, University of Campania “Luigi Vanvitelli”, Italy.

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