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Partial Lockdown and the Spread of Covid-19: Lessons From the Italian Case

Edoardo di Porto
Paolo Naticchioni
Vincenzo Scrutinio

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Economic and Social Research Council

Abstract
This paper investigates the effect of exemption of essential sectors from the lockdown enacted in Italy in Spring 2020 on COVID-19 infections and mortality. We exploit the distribution of the density of essential workers across provinces and rich administrative data in a difference in difference framework. We find that a standard deviation increase in essential workers per square kilometre leads to about 1.1 additional daily registered cases per 100,000 inhabitants. In addition, we show that a similar change in density leads to 0.32 additional daily deaths per 100,000 inhabitants. Back of envelope computations suggest that about one third of the Covid-19 cases in the period considered could be attributed to the less stringent lockdown for essential sectors as well as about 13,000 additional deaths, with an additional 107 million Euros in direct expenditure for the National Health System. In addition, we find that these effects are heterogeneous across sectors, with Services having a much larger impact than Manufacturing, and across geographic areas, with smaller benefits in areas less affected by the pandemic. These results are stable across a wide range of specifications and robustness check.

Key words: COVID-19, lockdown, essential sectors
JEL Codes: J18; I18

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Edoardo di Porto, CSEF, INPS and University of Naples Federico II. Paolo Naticchioni, NPS, IZA and University of Roma Tre. Vincenzo Scrutinio, Centre for Economic Performance, London School of Economics, IZA and University of Bologna.

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1 Introduction

While facing the Covid-19 epidemic governments relied on a wide range of non-pharmaceutical interventions in the attempt to slow down the pace of infections. Social distancing, lockdown, and a temporary stop to some economic activities have long been among the most common and widely used tools to confront infectious diseases (Cipolla 2012; Hatchett et al. 2007), and played an important role in the current circumstances. These measures entail, however, large costs as suspension of economic activity leads to loss in revenues, and unemployment. Governments, hence, need to carefully consider the trade-off between health benefits and economic losses. In this article, we aim at contributing to this debate by focussing on the health costs, in terms of higher contagion rates, from the exclusion of essential economic activities from a nationwide lockdown.

In many countries, governments imposed strong limitations to circulations of people. While social distancing measures de facto implied a stop to several sectors (e.g restaurants, pubs, hairdresser etc), in some cases, restrictions were explicitly extended to many productive activities. For several months, Italy (Bertacche et al. 2020), Spain (Marcos 2020), France (Martinier et al. 2020), but also India (The Economic Times 2020) and US states, such as California (Taryn 2020), allowed only a limited set of essential sectors to keep operating to limit the circulation of workers. This had important economic costs and determined a heated debate among entrepreneurs, legislators, and the medical expert community (Wong 2020). In addition these measures are likely to be a relevant topic in the near future: at the height of the epidemic in 2020 summer, more than 150 US medical experts, practitioners, and scientists called for a suspension of all non-essential economic activities in order to reduce infections (Erdman et al. 2020),[1] while, as a second wave of cases surges in Europe and other countries, several govermnets have already reintroduced local (France, UK) or national (Israel) lockdowns.

Despite the crucial importance of this question from a public policy perspective, the assessment of the impact of the continuation of economic activity has so far received limited attention in empirical studies. In this work, we contribute to investigate this issue by estimating the cost of

[1]For the full text, click here.

allowing a partial continuation of the economic activity in terms of additional reported infections and overall mortality. To do so, we exploit the distribution of essential sectors at province level (NUTS3 - according to European Regional Classification) in Italy on the local dynamic of the pandemic using a difference-in-difference strategy. The distribution of essential economic activity prior to the onset of the contagion is arguably exogenous to the current dynamic of infections, and it, hence, offers an ideal identification framework.

We use as our main measure of the presence of essential workers in the province the density of essential workers, measured as the number of workers in essential sectors per built square kilometre, which accounts for both the local numerosity of these workers and their concentration. We also experiment with other measures (namely, the share of essential workers in the population), and results are consistent. We find that a higher density of essential workers leads to higher number of local contagions with about 0.27 additional daily cases per 100,000 inhabitants for one hundred workers in essential sector per built square kilometre. In addition, the same change in density of essential workers leads to 0.076 additional deaths per 100,000 inhabitants. These are sizeable contributions: a standard deviation change in the density of essential sectors (420 workers per built square kilometre) leads to a 18.5% increase in daily cases with respect to the average infections after the policy implementation (5.97 per 100,000 inhabitants), and to 7.5% increase in daily mortality with respect to average mortality in the same period (4.3 deaths per 100,000 inhabitants). Back of the envelope computations suggest that about one third of all registered COVID-19 cases between the 22nd of March and the 4th of May could be attributed to the less stringent lockdown for these workers. This was also associated with an additional 13,000 deaths. The estimated direct economic costs for the National Health system correspond to about an additional 107 million Euros, which suggests moderate direct costs for the national health system. This assessment, however, neglects several aspects of the impact of the epidemic on the government budget, and it should be considered a lower bound. Results are heterogenous across geographic areas, with smaller costs in macro areas marginally touched by the pandemic, and across sectors. Indeed, while manufacturing had a trivial impact on the contagion, services, where relationship with co-workers and clients was likely more direct, had a much stronger impact on the number of new daily cases and mortality. As mitigating the economic costs of non-pharmaceuticals interventions is a crucial concern for policy makers, this result offers possible perspectives for more targeted shutdown of economic activities. Isolating which sectors show the higher risk of infection and focussing policies on them would indeed lower the economic costs of these policies, while preserving most of their benefits.

These results are robust to a wide range of identification and robustness checks. We exclude that results are driven by local time varying policies or trend breaks in contagion with respect to other variables, which might be correlated with our variable of interest. Moreover, provinces with different density of essential workers do not show differential trends prior to the introduction of the policy, which further supports our identification strategy.

This work contributes to a growing literature assessing the impact of policy measures to face the Covid-19 pandemic. Several studies exploit theoretical models to assess the impact of lockdown measures on the spread of the virus and on the economy. Ferguson et al. (2020) focus on the role of different non-pharmaceutical to curb contagions, while Acemoglu et al. (2020) and Greenstone and Nigam (2020) assess the characteristics of an optimal lockdown and its monetary gains for society from lower mortality. Other works investigate empirically the role of public policies to contain the contagion. In their seminal work, Hatchett et al. (2007) provide evidence on the role of public policies in containing the Spanish flu contagion in the US. Early work on China by Fang et al. (2020) show that mobility restrictions limited the spread of the disease to other areas. Hsiang et al. (2020), instead, provide a cross-country (China, South Korea, Iran, Italy, France, and the United States) analysis of COVID-19 policies. Their estimates suggest that policy response prevented about 60 million of cases. Several articles investigated the effects of Shelter-in-Place policies in the US (Friedson et al. 2020; Dave et al. 2020a; Dave et al. 2020b; and Dave et al. 2020c), and they find that these interventions, which encompass restrictions to mobility as well as closure of non-essential economic activities, reduce contagions, and, more imprecisely, mortality. They also tend to be more effective in densely populated areas, and early on in the diffusion of the disease. Finally, on the Italian case, Bonaccorsi et al. (2020) find that lockdown measures had a strong negative impact on mobility especially in municipalities with higher fiscal capacity and in those with higher inequality.

We believe our work provides several contributions to the existing literature. First, although a number of studies assessed the effects of Shelter-in-Place policies, which often encompass closure of non-essential sectors, no study has so far isolated the losses from lower constraints on economic activity. In a situation where countries find increasingly difficult to implement strict limitations due to budget and welfare concerns, understanding to what extent governments could limit their intervention on the economy to curb infections is extremely relevant. Our study provides novel evidence in addressing this relevant policy question in a clear causal framework. Second, our estimates concern one of the most affected developed countries by the COVID-19, which shares many similarities with other developed countries in terms of demographics, economic structure, and institutions. This increases the relevance of these results from a policy perspective. In addition, while some evidence is available for the US, much less is available for Europe, although many countries were severely affected by the pandemic. Third, Italy appears to be in an advanced stage of the pandemic, so these estimates are likely to provide a more encompassing picture of the overall effects of these policies. Finally, we use rich administrative data which allow for a precise assessment of our effect of interest.

The rest of the paper is structured as follows: Section 2 describes the data; Section 3 reports our empirical strategy; Section 4 presents our main results; Section 5 reports our robustness checks, and, finally, Section 6 concludes.

2 Data

This study is based on rich administrative data from the Italian Civil Protection and INPS (Italian Social Security Institute) administrative data.

Throughout the analysis, we will consider two main outcome variables: the number of newly reported COVID infections, and the number of deaths. First, we obtain the number of COVID-19 cases for the 106 Italian provinces from the Civil Protection website. This includes daily information on new infection at provincial level but also related deaths, hospitalized patients, and tests at regional level (NUTS 2). The last information is particularly salient as it allows to capture possible increases in positive cases due to a higher frequency of tests rather than infections. We use data from the 24th of February, day in which the data collection on COVID-19 cases started up to the 5th of May 2020, as most restrictions to local mobility were lifted on that date. Our main analysis is based on the new cases of COVID-19 for 100,000 inhabitants, which accounts for the different population across provinces, and it is a classical measure of incidence in the epidemiological literature. Reported cases are likely to be an underestimation of the actual number of infections as, in many cases, the disease led only to minor symptoms or was entirely asymptomatic. The number of reported cases, however, should reasonably capture the most severe cases, which are relevant from a health analysis perspective. We also believe that this variable could give us more direct information on the effects of the policy: indeed, the lockdown might affect mortality through other channels such as traffic fatalities (Oguzoglu 2020) or other disease, which are diagnosed or treated with delay due to the pandemic emergency (Al-Quteimat and Amer 2020). Mortality is, however, extremely relevant, and it is a crucial outcome from a welfare perspective. Hence, we extend our main analysis to assess the effect of presence of essential sectors on mortality. To this purpose, we obtain daily data at municipality level for deaths between 2017 and end of May 2020 from Social security records. We also get a few demographic information such as gender and age of the deceased. No information is unfortunately available on the cause of death. For homogeneity with contagion data, we aggregate this information at province level.

Finally, we combine this information with rich administrative data on the universe of private non-agricultural employees from Italian Social Security archives. More specifically, we rely on Uniemens mandatory forms, which firms submit monthly to social security for social contributions computation purposes. The data contain rich information on workers' characteristics, together with some information at firm level, such as the sector of activity, and the municipality where the worker is located. Due to data availability, we use data from 2018 as a proxy for the sectoral distribution at the beginning of 2020. We obtain the number of workers in essential sectors, and then normalize it by the built square kilometre in the province, which is drawn from the Global Human Settlement Layer of the European Commission (Corbane et al. 2018). This provides us with a measure of density of the essential economic activity.[2]

[2]We provide a sensitivity of the estimates to changes in the definition of this variable in Table 4. Results are

Table 1 reports summary statistics for our main variables of analysis. Both our main dependent variables show a substantial variability, and they are strongly rightly skewed. This highlights the strong time and geographic variability of the phenomenon under study. The pandemic had a relevant geographic dimension with a very strong impact in some northern regions. The density of workers in essential sectors also shows marked differences across provinces, and it ranges between 200 and 2200 workers per built square kilometre. On average, there are about 700 essential workers per built square kilometre per province. This number might appear quite a large but two considerations are in order: first, although the surface of a province is generally sizeable, the built surface is actually a small share of it;[3] second, a relatively large share of the economy was considered essential. Among the private sectors employees, the share working in an essential sector goes from a minimum of 28% to 60%. On average about 50% of the employees work in sectors considered essential. For more information on the geographic distribution of the density of essential workers, we remand to Figure B1 in the Appendix. The density is generally higher in the northern part of Italy, but several Southern regions show levels comparable to those in the North of the country.[4]

3 Methods

The increase in COVID-19 diffusion during February and early March 2020 led the Italian government to implement strict policies to slow down the pace of infections. These measures were ratified with two different laws, on the 9th and 22nd of March 2020 (d.P.C.m. 8/3/2020, and d.l. n. 6/2020): the former prohibited large gatherings in public and private spaces, sport events, and it suspended educational activities at schools with a few additional limitations, such as closure of restaurants and bars during the evening; the latter implemented a strict lockdown. More specifically, the law imposed a strict lockdown for the population, and it ordered an immediate suspension of all commercial and industrial activities, but for "essential" sectors (see

consistent with the main estimates.

[3]In the case of Rome, for example, the province encompasses an area of about 5,360 square km but only 746 square km are actually with buildings.

[4]For the sake of comparision, we also report the population density at the start of 2020 (100 of population per built square kilometre) in Figure B2 in the Appendix. Although there is a strong correlation between these two measures (0.72 correlation coefficient), we can also see relevant differences in the geographic distribution between these two variables, which allow us to isolate the effect of essential workers density.

Table A1 in the Appendix for a full sector list). Firms in all other sectors could remain active only in smart working, or if they received a special authorization for specific reasons (and ensured that employees would respect regulation on social distancing at work). In addition, individuals could not leave for a different municipality, but for proven work or emergency reasons.

In this analysis, we exploit the distribution of the essential sectors at provincial level to investigate the causal effect of the continuation of economic activities on COVID-19 contagion. To this purpose, we implement a standard difference-in-difference econometric strategy in line with recent recommendations from the literature (Goodman-Bacon and Marcus 2020): we compare changes in the number of infected individuals in provinces with higher and lower density of workers in essential sectors in the periods before and after the implementation of the lockdown law (March 22nd). This allows us to identify the causal effect of the essential sectors under the assumption that the number of new cases would have shown a similar trend across provinces, if no sectors had been exempted from the lockdown ("parallel trend" assumption). In practice, we estimate the following equation:

$$
\begin{aligned}
\Delta y_{jt} = \alpha + \beta_1 post03/22_t + \beta_2 Ess.perKm2_j + \\
+ \beta_3 post03/22_t X Ess.perKm2_j + W_j \zeta + \\
+ X_{jt}\gamma + \sum_{h=1}^{p} \delta_p EpTrend^{p}_{jt} + \theta_t + \eta_j + \varepsilon_{jt}
\end{aligned}
\quad (1)
$$

where the dependent variable is the change of the number of individuals positive to the COVID-19 virus per 100,000 inhabitants, $post03/22_t$ is a dummy which takes value 1 in the period after the 22nd of March 2020, and $Ess.perKm2_j$ is a variable which captures the density of workers in essential sectors, in terms of hundred workers in essential sectors firms per square kilometre. The β_3 coefficient is our parameter of interest: it represents how many additional new cases per 100,000 inhabitants a province experienced for an additional one hundred workers in essential sectors per square km. We also control for confounding factors such as population density (inhabitants at start of 2020 per built square kilometre), and share of population above

65 or below 12 years of age (W_j), the number of COVID-19 tests, number of healed or deceased patients at regional (NUTS2) level (X_{jt}), fourth order polynomial trends ($EpTrend^p$), day (θ_t), and province (η_j) fixed effects, which account for any time constant differences across provinces.[5] Trends start from the first day of positive case of COVID-19 case in the province to account for the dynamic of the epidemics from the local onset of the contagion. We cluster standard errors at province level, and weight observation by the population of the province at start of 2020 to obtain nationally representative estimates.

Our policy setting provides several advantages in terms of identification. First, the policy was implemented nationwide, so it is not correlated in both timing and intensity with our main variable of interest, that is the density of essential workers measured before the start of the pandemic. Second, the policy introduction was sudden, and this left local authorities and businesses little room to adjust pre-emptively to its implementation. A few measures were introduced before the 22nd of March at local level. These were, however, confined to a few municipalities where the first cases were registered (the so-called "red zone"). Some restrictions (suspension of large gatherings, sport events, etc.) were later introduced for a few regions (1st of March), but they were soon extended to the whole national territory (8th of March). In short, additional interventions and precautionary behaviours in specific areas were generally short lived and milder with respect to the later nationwide lockdown. Moreover, we flexibly control for time specific regional differences with a set of fixed effects, and this does not affect our main conclusions. Another possible issue is the presence of geographic spillovers: individuals travelling to different locations for work might spread the infection to other localities, and this might create downward bias[6] in our estimates as local contagion is then diffused to other areas. Commuting for work in this sense might be problematic. In this regard, it is important to keep in mind several elements. First, mobility to different municipalities was heavily restricted during the lockdown, and individuals could leave their municipality only for undelayable work, health,

[5] Note that both β_2 and ζ cannot be estimated in the full model due to the presence of province fixed effects. Indeed, the respective variables are constant in our period of observation. This does not harm our identification framework, and we report these less encompassing specifications to give a sense of the role of this important controls on our parameter of interest.

[6] In this framework, we expect workers to commute to locations with higher density of essential sectors, and then move back to locations with lower density. This would determine a higher number of cases with respect to the predicted from the local density of workers in essential sectors.

or emergency reasons. Bonaccorsi et al. (2020) showed that mobility strongly declined during the period of the lockdown. Second, our level of geographic aggregation reduces the possibility of downward bias in our estimates. Italian workers show a substantial mobility for work reasons, and about 50% of workers commute to a different municipality for work in 2017 (based on reports from the National Statistical Institute; ISTAT 2018). However, this mobility tends to be relatively local: about 20% travelled outside province. This kind of concerns is, hence, further reduced. Finally, we tackle this issue directly by accounting for the presence of essential sectors in neighbouring provinces, and our main results are unaffected, which further reduces worries about workers mobility.

4 Results

The different exposure to essential industries had an important impact on the number of reported COVID-19 cases. We report the estimates for our main equation (Equation 1) in Table 2. An additional one hundred workers per square kilometre leads to about 0.4 new cases per 100,000 inhabitants per day. The coefficient is only mildly affected by the introduction of population density and local age structure of the population in Column (2), and it declines to about 0.25 once fixed effects are included in Column (3). It remains relatively stable thereafter. To give a better quantitative sense of these results, we can look at what would happen with a standard deviation change in the density of essential workers: this would imply about an additional case per day per 100,000 inhabitants, which corresponds to about 18.5% of the average number of daily cases in the period after the policy implementation (5.97 per day). Regional controls for number of tests only mildly affect the coefficient as reported in Column (4). Column (5) includes daily fixed effects interacted with 20 regional fixed effects, exploiting within region variability across provinces in the density of essential workers. This is particularly salient as, although the Health system is national, regions have substantial competences concerning the local provision and management of health services. These fixed effects allow us to account for any additional regional policies at daily level, which could have been reason of concern if they were correlated with our variable of interest. Also in this case, the coefficient is close to our original specification. In all these cases, this effect is highly statistically significant. Finally, in Column (6), we decompose the effect by macro area. This is a relevant dimension as the northern part of the country was hit by the pandemic more severely and earlier, and it shows stronger economic indicators with respect to southern regions. The effect of the lockdown was similar across areas with a possibly lower impact in the South. This difference, however, is not precisely estimated. This provides suggestive evidence that the lockdown might have led to limited gains in areas which had been largely spared by the contagion (the South).

We then move to understand how the spread of the contagion affected mortality. Hence, we estimate our preferred specification (Column 3 of Table 2) on the number of daily deaths by province per 100,000 inhabitants. Estimates are reported in Table 3. The presence of workers in essential sectors had a relatively small but highly statistically significant effect on local mortality rate, with an additional one hundred workers leading to 0.076 deaths per 100,000. This is equivalent to 1.76% increase with respect to the average mortality rate across provinces. The effect is strongly heterogenous across age groups: the highest effect is registered among people who are 80 years of age or above (Column 2); a smaller effect can be found for those between 60 and 79 years of age (Column 3); and no effect is detected for those below 60 years of age (Column 4). This is in line with mortality statistics from the National Health System which reported a median age of deaths due to Covid-19 around 80 years of age. Only small differences can be seen between males and females, with female mortality being slightly more affected (Column 5 and Column 6). The detrimental effect on mortality was more pronounced in the North and in the Centre of Italy, while no gains can be detected in the South. This is in line with previous evidence on contagions and it provides a clearer evidence that gains from stricter lockdown could be different across areas. Finally, we focus on a more narrow definition of mortality by looking at excess mortality in the province at daily level with respect to average mortality in the same calendar and province in the 5 years before the pandemic (2015-2019). Results, reported in Column 8, show that estimates are perfectly in line with our main results.

This aggregate effect of the density of economic activity hides a substantial sector heterogeneity. Workers in different sectors interact to a different extent with other individuals, and this is reflected in how they influence the spread of the disease. In order to assess this margin, we decompose our main difference-in-difference term in several terms which describe the density of workers in each sector at the local level. We restrict our attention, also in this case, to essential sectors, so workers in "Manufacturing" represent workers who were employed in "Manufacturing", in essential subsectors. We group sectors according to their NACE Rev. 2 classification.[7] To provide a clearer visual interpretation and ease interpretation, we multiply coefficients and standard errors by the standard deviation of the density of the respective sector and plot the resulting estimates with their 95% confidence interval in Figure 1.[8] Panel a reports the effect on contagion while Panel b reports the effect on mortality. The figure points at a strong heterogeneity across sectors: while manufacturing workers seem to have no impact on contagion, other sectors such as health and social work and other services to firms and individuals[9] played a much more relevant role. A standard deviation change in "Other Services to firms and individuals" leads to about 4 daily additional cases per 100,000 and 1.5 additional deaths. The more direct interaction with both co-workers and clients, without the protective precautions of the health sector, might explain this large heterogeneity with respect to other sectors. Due to their strict contact among co-workers and direct exposure to the disease, it appears reasonable that a stronger presence of health workers led to more cases. Note that, as the number of workers in the health sector is computed prior to the onset of the epidemic, this does not reflect the market response to the local outbreak of Covid-19 infection. It is, however, also possible that the effect of health sector is related to the proximity of sick patients, and more susceptible individuals in hospitals and nursery homes. It is hence more difficult to draw policy conclusions in this respective, but this is a minor concern as the share of the Health sectors is small, and it is anyway unlikely that policymakers could act on it during the epidemic. Similar concerns, to a different extent, could be related to part of the workers involved in "Other services" activities. Some activities, such as food retail commerce, are necessary for social order, especially in a stress period such as the one determined by the contagion, and policy makers will

[7] For the relative contribution of each sector to the overall density see Figure B3 in the Appendix.

[8] For the raw coefficient see Figure B4 in the Appendix.

[9] This category collects three different sectors: Financial and Insurance activities; Wholesale and Retail Trade; Professional, Scientific and Technical Activities. Other category includes: Agriculture, Forestry and Fishing; Water Supply; Sewerage, Waste Management and Remediation Activities; Other Service Activities; Construction; Electricity, Gas, Steam and Air Conditioning Supply; Information and Communication; Education; Public Administration and Defence; Compulsory Social Security; Mining and Quarrying.

have little margin to act on them with extreme measures such as closure. Thus, the contagion determined by these sectors will be difficult to control and other interventions (e.g. stricter controls or access rationing) could be considered.

Based on the available evidence, we can provide some back of the envelope computation of the contribution of essential sectors to the pandemic in Italy. We use our measure of workers' density, and the estimate from Column (2) of Table 2. We multiply the coefficient of the interaction term by the density of essential workers by province for the period after the 22nd of March, and by the population in the province (in 100,000). We then add up all these daily contributions for the whole period considered (22nd of March to 4th of May) and for all provinces. Cases related to essential sectors appear to represent a relevant share of COVID-19 registered cases in Italy between the 22nd of March and the 5th of May, about 30% (47,000 over 150,000). This shows that the continuation of economic activity had a non-trivial impact the development of the contagion. Similarly, we can compute the contribution of the COVID-19 to overall mortality in Italy in the period under study. Based on our estimates, we find that essential sectors led to additional 13,000 deaths or about 13% of the overall mortality (105,013 deaths between the 22nd of March and the 4th of May). This is a substantial contribution which is informative about the substantial trade-off policy makers face in their lockdown decision. Note that this effect conflates all causes of deaths, and crowding out of other medical services, social isolation, and economic deprivation could have all contributed to our figure. As we lack data on causes of death, we remand this promising line of research to further studies.

It would then be useful to quantify the economic costs in terms of health expenditure. This requires a number of assumption: first, we assume a constant hospitalization rate of COVID-19 patients (20%) and homogeneity of the cost for the healthcare sector.[10] We assume a 20% hospitalization rate, a 3% ICU access, and a 1.5% mortality (Istituto Superiore Sanità 2020). We further assume a 20 days average stay in ICU for admitted patients, as recorded in French data (Lapidus et al. 2020). After accounting for all these factors, the overall direct cost for the additional COVID-19 cases are close to 107 million of Euros, which seems small with respect

[10]Throughout this analysis, we use cost estimates from Cicchetti and Di Bidino (2020), which assess the cost of hospitalization based on the standard cost of the resources absorbed by one patient with a specific treatment.

to the overall Health sector budget. In face of these estimates, the choice to keep the "essential sector" in the economy active during the pandemic seems to come at relatively contained cost for the Health sector. Such interpretation does, however, present some important limitations: it does not account for the cost of delayed services to other patients, which might be substantial in the long run; it does not consider for possibly long term rehabilitation or health consequences of the COVID-19 infection on healed patients; it does not consider welfare costs from mortality, and related lifetime earnings and expenditures. A fully comprehensive assessment of these elements is, however, beyond the scope of the current study.

5 Robustness checks

We perform a series of robustness checks for the validity of our research design and the stability of our estimates.

As a first step, we assess whether the density of workers in essential sectors determined differential trends in contagion even before the implementation of the partial lockdown on economic activity. To this purpose, we estimate the following variation of Equation 1:

$$\begin{aligned} \Delta y_{it} = \alpha + \sum_{h=v}^{m} \beta_{1h} I(date = h) + \beta_2 Ess.perKm2_j + \\ + \sum_{h=v}^{m} \beta_{3h} I(date = h) X Ess.perKm2_j + X_{jt}\gamma + \\ + \sum_{h=1}^{p} \delta_p EpTrend_{jt}^{p} + \theta_t + \eta_j + \varepsilon_{jt} \end{aligned} \tag{2}$$

where $I(date = h)$ is a set of date dummies. The set of coefficients β_{3h} provide a test for our parallel trend assumption, as well as information concerning the dynamic of the effect. To gain stability in the coefficients and statistical power in their estimation, we group dates in in three days period, and we use the period between the 5th of March and the 7th of March as a reference period. We report coefficients for the interaction terms in Figure 2 (Panel a) with their 95% confidence interval. The results are comforting. On the one hand, coefficients for the period before the 22nd of March are negligible in size and far from being statistically significant. This supports our identification assumption. On the other hand, coefficients for periods after the 22nd are consistently larger and highly statistically significant after about 10 days from the implementation of the policy. Two elements can help us rationalize this result: first, the dynamic of infections is non-linear, it might take time for the effects of the policy to be statistically detectable in the data; second, recent medical literature shows that it might take up to 12 days from infection for the onset of the symptoms in COVID-19 positive individuals, with a median of 5 days (Lauer et al. 2020), and an additional 4/5 days for the symptoms to worsen (Chen et al. 2020). Both these factors can explain the observed delay in the response of contagions to the policy. Results for mortality, reported in Panel b, are consistent with the pattern for reported cases, and they do not show any pre-trend in deaths per 100,000 inhabitants. A remaining worry is that this dynamic in mortality reflects different seasonal local patterns, and our results would then be conflating both the effect of the essential sectors, and the ordinary behaviour of mortality rates. To further explore this possibility, we perform a placebo test with mortality data from 2019, and estimate the same model described above by defining the post period as the dates between 22nd of March 2019 and the 4th of May 2019. Coefficients, reported in Figure 3 are in line with our expectations. The effects are small and only in a very small minority of cases statistically significant at 5% and negative. This further corroborates our interpretation of the results.

Then, we move to further validate our estimates. To do so, we perform a battery of robustness checks, and report the results in Table 4. We report our baseline result, Column (3) of Table 2, in Column (1) for the sake of comparison. As a first step, we assess whether the presence of specific regions or periods drive our estimates. So, we exclude the whole Lombardy and Piedmont, which are the two regions mostly affected by the pandemic, in Column (2), and weekends, which can be peculiar days in terms of tests implemented and of recording of cases, in Column (3). Main estimates are barely affected. Then, we assess whether the observed pattern could be explained by additional factors, which might be related with the density of essential sectors in the province. We include several characteristics of the province together with interactions with the post 22nd period. If the observed pattern in the data is indeed related to other trends in observable characteristics of the province, then we would expect that the additional difference in difference terms should at least partly absorb the effect of the density of workers in essential sectors. We include population density per built square kilometre in Column (4), share of individuals in the province above the age of 65 in Column (5), Share of children below 12 in Column (6) and the average age of individuals in the province in Column (7). Coefficients have generally the expected sign with older age associated with a higher number of new daily cases. Surprisingly, population density does not appear to have an effect, although the presence of a strict lockdown in the period considered might dampen the impact of this dimension. More importantly, our main effect is stable, and it changes only marginally with the inclusion of these additional terms. Results are also consistent if we interact these characteristics with date dummies in a more flexible specifciation.[11] We also exclude the health sector in Column (8). This might be mechanically related with new cases, and it is also less likely that policy makers might act on this sector in the case of epidemic, as discussed above. Our results are almost unchanged. We experiment with an additional measure of the prevalence of essential workers in province by normalizing for the population in Column (9). Results are in line with main ones, and quantitatively very consistent: a standard deviation change in the two measures implies a very similar number of additional daily cases (about one additional case). Then, we exclude population weights in Column (10), which leads only to negligible variations in our estimates. Finally, we consider possible geographic spillovers. During the period of the lockdown mobility across municipalities was strongly reduced and, even in ordinary times, mobility across provinces for work reasons is smaller than mobility across municipalities, although non-negligible (20% of workers move across provinces while about 50% move across municipalities). As mobility of infected workers to different provinces could lead downward bias, we assess whether the density of essential workers in neighbouring provinces affected the local dynamic of the epidemic. To do so, we compute the weighted average of density of essential workers in bordering provinces (weighted by the number of essential workers in those provinces), and we include this variable together with its interaction with the post dummy in our equation. This does not seem to affect our main result, and the additional interaction term is

[11] Estimates are reported in Table A2 in the Appendix.

not statistically different from zero. This is in line with our expectation of lower geographic mobility for work related reasons, and it provides further supportive evidence for our estimates. The same set of robustness checks for mortality is reported in Table A3 in the Appendix. As results are in line with evidence reported above, we do not elaborate further on them.

Overall, these results provide comforting evidence about the reliability of the causal interpretation of our estimates, and about the stability of our quantitative findings.

6 Conclusions

This article exploited detailed administrative data on Italy to investigate the impact of selective suspension of economic activity by sector in the Italian economy. Indeed, while many activities were forced to close under a strict lockdown law, sectors which were deemed essential for the economy were allowed to keep operating. Italy was among the countries most severely affected by the COVID-19 epidemics, and it offers an excellent case study for other advanced economies. It presents many similarities with other developed economies both in institutional aspects as well as in terms of population and economic structure. We exploit detailed administrative data, and we implement a difference-in-difference strategy to assess the impact of the density of essential workers on new daily detected COVID-19 infections. This strategy compares the change in average number of new positive cases in provinces with higher exposure to essential sectors to the change in provinces where these activities were less present.

Our results show that a stronger presence of essential activities led to a higher number of contagions: an additional 100 workers per square kilometre in essential sectors generated about 0.27 additional daily cases. Overall, the contribution of these sectors was substantial for the epidemic, and we compute that about one third of new cases from between end of March and early May could be attributed to less stringent lockdown for these workers. At the same time, the opening of essential sector also impacted mortality, and the additional mortality represented about 13% of the overall mortality in the period of the implementation of the policy. This result is quantitatively important. The implied direct public health related economic costs stand at about 107 million Euros, which appear modest with respect to the overall Health expenditure (about 110 billion Euros). These estimates are, however, likely to be a lower bound and should be anyway taken with care. We find suggestive evidence that the effect of the policy was heterogeneous across geographic areas, with smaller detrimental effects in areas which were mostly spared by the epidemic at the time of the policy implementation, and across sectors. Essential services to firms and individuals show a much larger impact than manufacturing, hence the extension of the lockdown to these activities might have had a limited impact on the diffusion of the infection with large economic costs. The dynamic of new contagions was similar in provinces with different exposure to these sectors before the passing of the legislation, and a placebo test confirms that differential mortality patterns are not related to different epidemiological cycles across provinces. Both these results provide evidence of the lack of difference in pre-trends and supports our identification strategy. Results are stable across a wide range of robustness checks.

The Covid-19 epidemic proved to be a great challenge for policymakers, who acted with limited information about the impact and costs of several classical policy measure. Epidemics will likely remain a constant threat in the foreseeable future, and this calls for a renowned attention to the lessons that can be learned by the current situation Osterholm and Mark (2020). We believe this article provides some relevant contributions which might help frame future policy responses.

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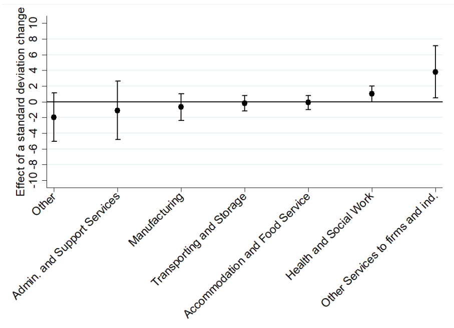
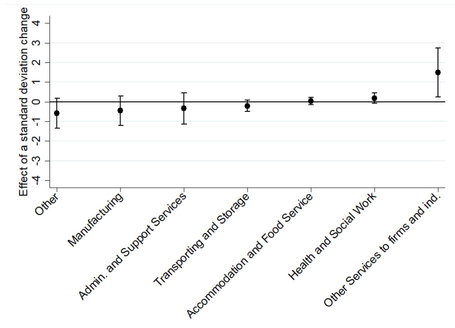
Figures

Figure 1: Effect of density of essential sectors on Covid-19 infections and mortality by sector: effect of standard deviation change



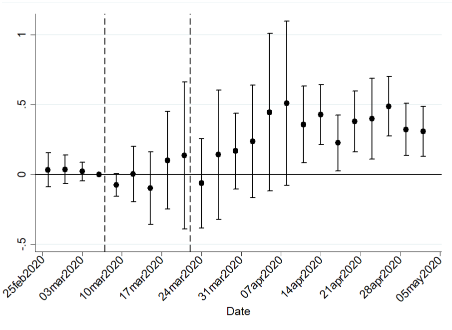
(a) Cases per 100,000 of population



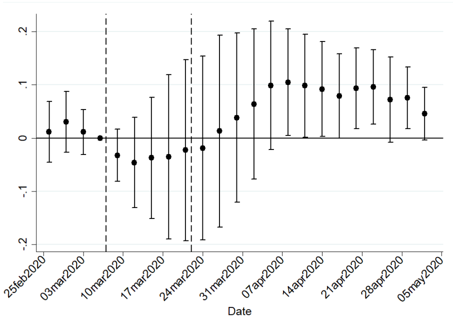
(b) Deaths per 100,000 of population

Note: Estimates for the effect of density of essential workers in different sectors on Covid-19 infections and mortality. Density of workers in essential sectors is measured as the number of workers (in hundreds) employed in essential sectors in 2018 per built square kilometre. Panel (a) reports effects for the number of reported cases for 100,000 inhabitants while Panel (b) reports the effect on number of deaths per 100,000 inhabitants. Reported coefficients and standard errors computed for a standard deviation change in the density of workers in a specific sector. The regression includes a 4th order polynomial trend from the first registered Covid-19 case in the province, and date and province fixed effects. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Observations weighted by the population in the province at the start of 2020. Confidence intervals at 95% based on standard errors clustered at province level reported. Services to firms and ind. includes: Financial and Insurance activities; Wholesale and Retail Trade; Professional, Scientific and Technical Activities. Other category includes: Agriculture, Forestry and Fishing; Water Supply; Sewerage, Waste Management and Remediation Activities; Other Service Activities; Construction; Electricity, Gas, Steam and Air Conditioning Supply; Information and Communication; Education; Public Administration and Defence; Compulsory Social Security; Mining and Quarrying.

Figure 2: Density of essential workers and its effect over time on contagions and mortality



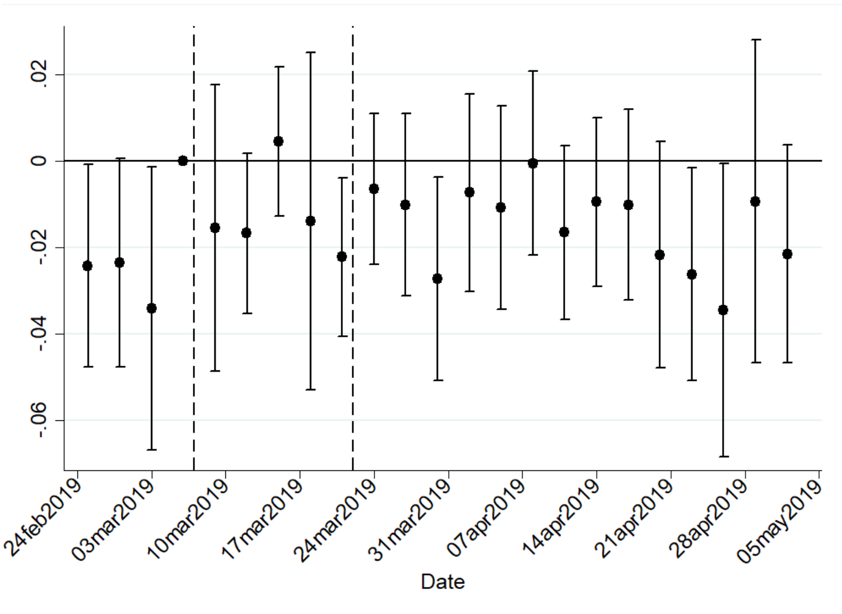
(a) Cases per 100,000 of population



(b) Deaths per 100,000 of population

Note: Estimates for the effect of the density of essential workers before and after the policy implementation as described in Equation 2 for 2020 on Covid-19 infections and mortality. Density of workers in essential sectors is measured as the number of workers (in hundreds) employed in essential sectors in 2018 per built square kilometre. Panel (a) reports effects for the number of reported cases for 100,000 inhabitants while Panel (b) reports the effect on number of deaths per 100,000 inhabitants. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Dates collected in three days groups to improve readability. The regression includes a 4th order polynomial trend from the first registered Covid-19 case in the province, and date (three days groups) and province fixed effects. The period between 5^{th} and the 7^{th} of March is used as a reference period. Observations weighted by the population in the province at the start of 2020. Confidence intervals at 95% based on standard errors clustered at province level reported.

Figure 3: Effect of density of essential workers on mortality in 2019



Note: Estimates for the effect of the density of essential workers before and after the policy implementation as described in Equation 2 for 2019 on mortality. We report the effect of density of essential sector workers on number of deaths per 100,000 inhabitants. Density of workers in essential sectors is measured as the number of workers (in hundreds) employed in essential sectors in 2018 per built square kilometre. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2019. Dates collected in three days groups to improve readability. The period between 5^{th} and the 7^{th} of March is used as a reference period. The regression includes a 4th order polynomial trend from the first registered Covid-19 case in the province, and date (three days groups) and province fixed effects. Observations weighted by the population in the province at the start of 2019. Confidence intervals at 95% based on standard errors clustered at province level reported.

Tables

Table 1: Summary statistics for main variables

Stats	Daily change COVID-19 cases	Daily deaths	Density essential workers
Mean	5.011	4.114	7.053
Sd	7.366	2.590	4.200
Minimum	0.000	0.000	2.242
25ht percentile	0.452	2.718	4.252
50ht percentile	2.089	3.413	5.704
75ht percentile	7.037	4.640	8.184
Maximum	95.159	30.097	22.492

Note: Summary statistics for main variables in the analysis. Both daily change in COVID-19 cases and Daily deaths by province are normalized by 100,000 inhabitants in the province on the 1st of January 2020. Density of essential workers is the number (in hundreds) of workers employed in essential sectors in 2018 per built squared kilometre. Observations weighted by the population in the province at the start of 2020.

Table 2: Effect of density of essential sectors on number of new daily COVID-19 cases per 100,000 inhabitants

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	New Cases	New Cases	New Cases	New Cases	New Cases	New Cases
’00 Ess. per Km2 X post 03/22	0.421***	0.413***	0.266***	0.261***	0.296**	0.250***
	(0.070)	(0.069)	(0.076)	(0.090)	(0.130)	(0.070)
’00 Ess. per Km2 X post 03/22 X Centre						-0.004
						(0.125)
’00 Ess. per Km2 X post 03/22 X South						-0.103
						(0.098)
Observations	7,314	7,314	7,314	7,314	7,245	7,314
Mean Dep.	5.97	5.97	5.97	5.97	5.97	5.97
SD Essential	4.2	4.2	4.2	4.2	4.2	4.2
Controls	NO	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Date FE	YES	YES	YES	YES	YES	YES
Ep. Trend 4th	NO	NO	YES	YES	YES	YES
Reg. Controls	NO	NO	NO	YES	NO	NO
RegionXDate FE	NO	NO	NO	NO	YES	NO

Note: OLS regressions for the difference in difference model reported in Equation 1. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Dependent variable is the number of new reported Covid-19 cases per 100,000 inhabitants. Ess. per Km2 is the number of workers (in hundreds) in essential sector in the province per built square kilometre. Ep.Trend 4th is a fourth order polynomial for a trend since the first positive registered case of COVID-19 in the province. Controls include population per built square kilometre, share of population above 65 years of age, and below 12. Population is computed based on figures at the start of 2020. Regional controls are the daily number of tests, healed and deceased patients in the region. Region and date fixed effects are interactions between daily dummies and regional dummies. Observations weighted by inhabitants on the 1st of January 2020. Standard errors clustered at province level reported in parenthesis. Level of significance: ***, 0.01; **, 0.05; *, 0.1.

Table 3: Effect of density of essential sectors on daily number of deaths per 100,000 inhabitants

VARIABLES	(1) Deaths	(2) Above 79	(3) 60-79	(4) Below 60	(5) Male	(6) Female	(7) Deaths	(8) Exc. Deaths
’00 Ess. per Km2 X post 03/22	0.076***	0.749**	0.083**	0.002	0.072***	0.079**	0.081***	0.070**
	(0.028)	(0.328)	(0.032)	(0.001)	(0.027)	(0.032)	(0.028)	(0.027)
’00 Ess. per Km2 X post 03/22 X Centre							-0.016	
							(0.034)	
’00 Ess. per Km2 X post 03/22 X South							-0.082**	
							(0.036)	
Observations	7,314	7,314	7,314	7,314	7,314	7,314	7,314	7,314
Mean Dep.	4.3	38.37	5.48	.33	4.34	4.27	4.3	1.39
SD Essential	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Ep. Trend 4th	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
Date FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: OLS regressions for the difference in difference model reported in Equation 1. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Dependent variable is the number of deaths per 100,000 inhabitants. Ess. per Km2 is the number of workers (in hundreds) in essential sector in the province per built square kilometre. Ep.Trend 4th is a fourth order polynomial for a trend since the first positive registered case of COVID-19 in the province. Regional controls are the daily number of tests, healed and deceased patients in the region. Column 1 to 7 use as dependent variable the number of deaths per 100,000 inhabitants in aggregate, by age group or by gender. Column 8 uses as dependent variable the excess deaths for 100,000 inhabitants with respect to the average deaths per 100,000 by day and province in the 5 years before the pandemic. Observations weighted by inhabitants on the 1st of January 2020. Standard errors clustered at province level reported in parenthesis. Level of significance: ***, 0.01; **, 0.05; *, 0.1.

Table 4: Effect of partial lockdown of essential sectors on number of new daily COVID-19 cases: robustness checks

VARIABLES	(1) New Cases	(2) No Lombardy and Piedmont	(3) No Week Ends	(4) New Cases	(5) New Cases	(6) New Cases	(7) New Cases	(8) New Cases	(9) New Cases	(10) No Weights	(11) Neighbouring
’00 Ess. per Km2 X post 03/22	0.266***	0.274***	0.235***	0.357***	0.245***	0.267***	0.243***			0.253***	0.265***
	(0.076)	(0.088)	(0.076)	(0.089)	(0.064)	(0.067)	(0.067)			(0.088)	(0.086)
’00 Population per Km2 X post 03/22				-0.029							
				(0.022)							
% Above 65 X post 03/22					0.560***						
					(0.159)						
% below 12 X post 03/22						-1.254***					
						(0.431)					
Average Age X post 03/22							0.750***				
							(0.219)				
’00 Ess. (no health) per Km2 X post 03/22								0.283***			
								(0.082)			
# Ess. workers per ’00 inhab. X post 03/22									0.193***		
									(0.051)		
’00 Ess. per Km2 (Neigh.) X post 03/22											-0.022
											(0.184)
Observations	7,314	5,934	5,194	7,314	7,314	7,314	7,314	7,314	7,314	7,314	7,245
Mean Dep.	5.97	3.99	5.76	5.97	5.97	5.97	5.97	5.97	5.97	5.97	5.97
SD Essential	4.2	3.98	4.2	4.2	4.2	4.2	4.2	3.94	5.35	3.24	3.24
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Date FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ep. Trend 4th	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: OLS regressions for the difference in difference model reported in Equation 1. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Dependent variable is the number of new reported Covid-19 cases per 100,000 inhabitants. Ess. per Km2 is the number of workers (in hundreds) in essential sector in the province per built square kilometre. Ep.Trend 4th is a fourth order polynomial for a trend since the first positive registered case of COVID-19 in the province. Regional controls are the daily number of tests, healed and deceased patients in the region. Observations weighted by inhabitants on the 1st of January 2020. Column (2) excludes the two regions most affected by the COVID-19 epidemic (Lombardy and Piedmont, with, respectively, 12 and 8 provinces). Column (3) excludes Saturday and Sunday from the sample. Column (8) excludes the Health sector from the computation of essential workers per square kilometre. Column (11) considers the density of essential workers in neighbouring provinces weighted by the number of essential workers in those provinces. Standard errors clustered at province level reported in parenthesis. Level of significance: ***, 0.01; **, 0.05; *, 0.1.

A Tables

Table A1: List of Essential Sectors

ATECO CODE	LABEL
1	Agriculture and animal products
3	Fishing
5	Coal mining
6	Oil and Gas extraction
9.1	Support for oil and gas extraction
10	Food industry
11	Beverage industry
13.96.20	Technical textile and industrial products production
13.95	Textile excluding clothing
14.12.00	Work clothing production
16.24	Wood Packing production
17	Paper production
18	Printing and replication of recorded products
19	Coke and oil related products production
20	Chemicals production
21	Pharmaceuticals products
22.2	Plastic material production
23.13	Hollow glass production
23.19.10	Pharmaceutical and laboratory glass products production
25.21	Metal containers for heating production
25.92	Light metal packing production
26.6	Electromedical equipment production
27.1	Engine, power generators and tools for distribution and control of electricity production
27.2	Batteries and storage batteries production
28.29.30	Automatic machinery for packing and storage production
28.95.00	Machinery for paper industry production
28.96	Machinery for rubber industry production
32.5	Medical and dental tool production
32.99.1	Protective clothing production
32.99.4	Funerary tools production
33	Repair and installation for machinery
35	Distribution of gas and electricity
36	Collection and distribution of water
37	Sewers management
38	Waste collection and disposal
39	Waste management services
42	Civil engineering
43.2	Electrical and hydraulic system installation and management
45.2	Repair of auto vehicles
45.3	Commerce of auto vehicles parts and accessories
45.4	Motorcycle repair and commerce of parts and accessories
46.2	Wholesale commerce of live animals and raw materials
46.3	Wholesale commerce of food, beverage, and tobacco
46.46	Wholesale commerce of pharmaceutical products
46.49.2	Wholesale commerce of books and journals
46.61	Wholesale commerce of agricultural tools and machinery
46.69.91	Wholesale commerce of tools for scientific use
46.69.94	Wholesale commerce of tools fire and accident protection tools
46.71	Wholesale commerce of oil products and heating fuel
49	Land and pipe transport
50	Water transport
51	Aerial Transport
52	Stockage and support activities for transportation
53	Postal services

Table A1: List of Essential Sectors (cont.)

ATECO CODE	LABEL
53	Postal services
55.1	Hotel and similar activities
58	Publishing activities
59	Video, television programs production and recording activities
60	Broadcasting activities
61	Telecommunication
62	Software programming, information technology consulting and related activities
63	News services and information technology services
64	Financial services but insurance and pension funds
65	Insurance and pension funds
66	Auxiliary financial activities
69	Legal and accounting services
70	Management and consulting activities
71	Engineering and architecture services and consulting
72	Scientific research and development
74	Scientific and technical professional activities
75	Veterinary services
78.2	Temporary work agencies
80.1	Private surveillance services
80.2	Services related to surveillance activities
81.2	Cleaning and disinfestation
82.2	Call Centre
82.92	Packing services
82.99.2	Distribution of books and newspapers
82.99.99	Other services for firms support
84	PA and defence
85	Education
86	Healthcare
87	Social services for housing
88	Social services not for housing
94	di datori di lavoro e professionali
95.11.00	Computer repair and support
95.12.01	Phones repair and support
95.12.09	Other communication devices repair and support
95.22.01	Home electric equipment repairs and support
97	Domestic workers

Table A2: Effect of essential sectors on number of new daily COVID-19 cases: robustness with controls and date interactions

VARIABLES	(1) Pop Density	(2) Sharev Above 50	(3) Share Below 12	(4) Average Age
’00 Ess. per Km2 X post 03/22	0.359***	0.241***	0.263***	0.240***
	(0.090)	(0.065)	(0.070)	(0.068)
Observations	7,314	7,314	7,314	7,314
Mean Dep.	5.97	5.97	5.97	5.97
SD Essential	4.2	4.2	4.2	4.2
Ep. Trend 4th	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Date FE	YES	YES	YES	YES

Note: OLS regressions for the difference in difference model reported in Equation 1. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Dependent variable is the number of new reported Covid-19 cases per 100,000 inhabitants. Ess. per Km2 is the number of workers (in hundreds) in essential sector in the province per built square kilometre. Ep.Trend 4th is a fourth order polynomial for a trend since the first positive registered case of COVID-19 in the province. Regional controls are the daily number of tests, healed and deceased patients in the region. Observations weighted by inhabitants on the 1st of January 2020. Each column includes interactions between the control in the heading and daily dummies. Standard errors clustered at province level reported in parenthesis. Level of significance: ***, 0.01; **, 0.05; *, 0.1.

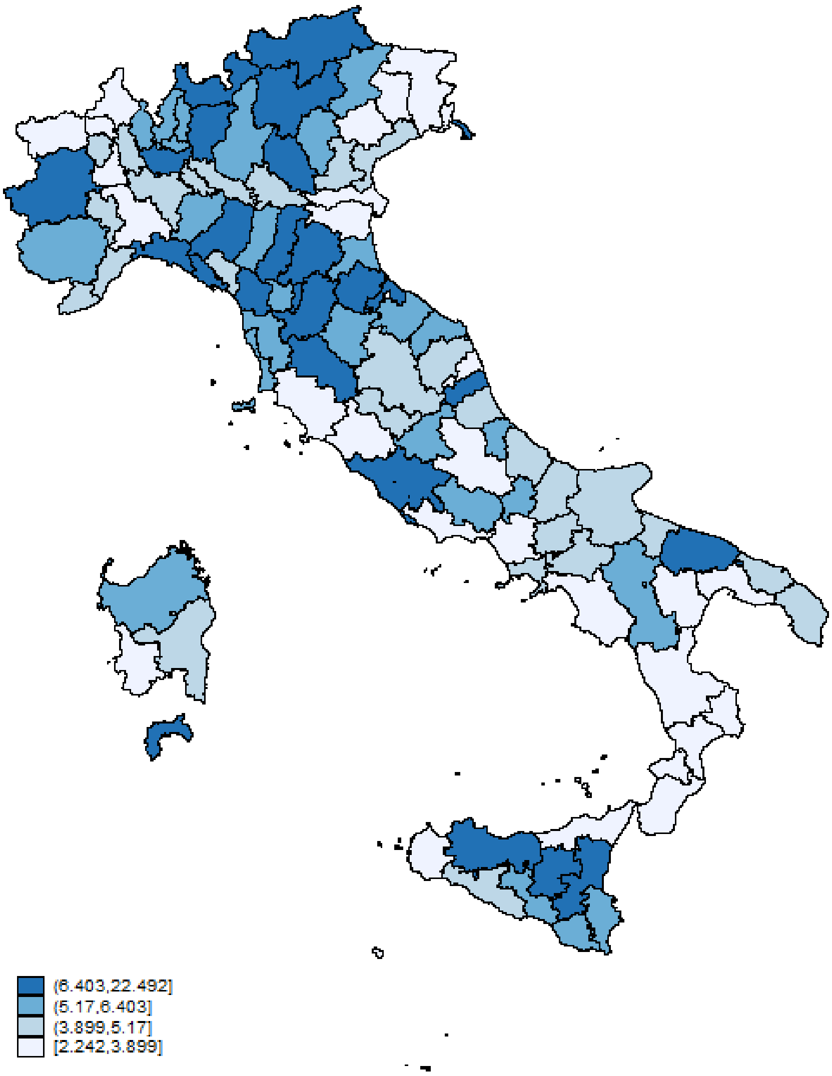
Table A3: Effect of essential sectors on number of deaths per 100,000 inhabitants: robustness

VARIABLES	(1) Deaths	(2) No Lombardy and Piedmont	(3) No Week Ends	(4) Deaths	(5) Deaths	(6) Deaths	(7) Deaths	(8) Deaths	(9) Deaths	(10) No Weights	(11) Neighbouring
’00 Ess. per Km2 X post 03/22	0.076***	0.051***	0.073**	0.106***	0.072**	0.076**	0.072**			0.071***	0.076***
	(0.028)	(0.019)	(0.030)	(0.031)	(0.030)	(0.029)	(0.030)			(0.023)	(0.022)
’00 Population per Km2 X post 03/22				-0.010							
				(0.007)							
% Above 65 X post 03/22					0.104**						
					(0.046)						
% below 12 X post 03/22						-0.235					
						(0.149)					
Average Age X post 03/22							0.136**				
							(0.065)				
’00 Ess. (no health) per Km2 X post 03/22								0.082***			
								(0.030)			
# Ess. workers per ’00 inhab. X post 03/22									0.054**		
									(0.021)		
’00 Ess. per Km2 (Neigh.) X post 03/22											-0.062
											(0.061)
Observations	7,314	5,934	5,194	7,314	7,314	7,314	7,314	7,314	7,314	7,314	7,245
Mean Dep.	4.3	3.56	4.32	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
SD Essential	4.2	3.98	4.2	4.2	4.2	4.2	4.2	3.94	5.35	3.24	3.24
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Date FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ep. Trend 4th	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: OLS regressions for the difference in difference model reported in Equation 1. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Dependent variable is the number of deaths per 100,000 inhabitants. Ess. per Km2 is the number of workers (in hundreds) in essential sector in the province per built square kilometre. Ep.Trend 4th is a fourth order polynomial for a trend since the first positive registered case of COVID-19 in the province. Regional controls are the daily number of tests, healed and deceased patients in the region. Observations weighted by inhabitants on the 1st of January 2020. Column (2) excludes the two regions most affected by the COVID-19 epidemic (Lombardy and Piedmont, with, respectively, 12 and 8 provinces). Column (3) excludes Saturday and Sunday from the sample. Column (8) excludes the Health sector from the computation of essential workers per square kilometre. Column (11) considers the density of essential workers in neighbouring provinces weighted by the number of essential workers in those provinces. Standard errors clustered at province level reported in parenthesis. Level of significance: ***, 0.01; **, 0.05; *, 0.1.

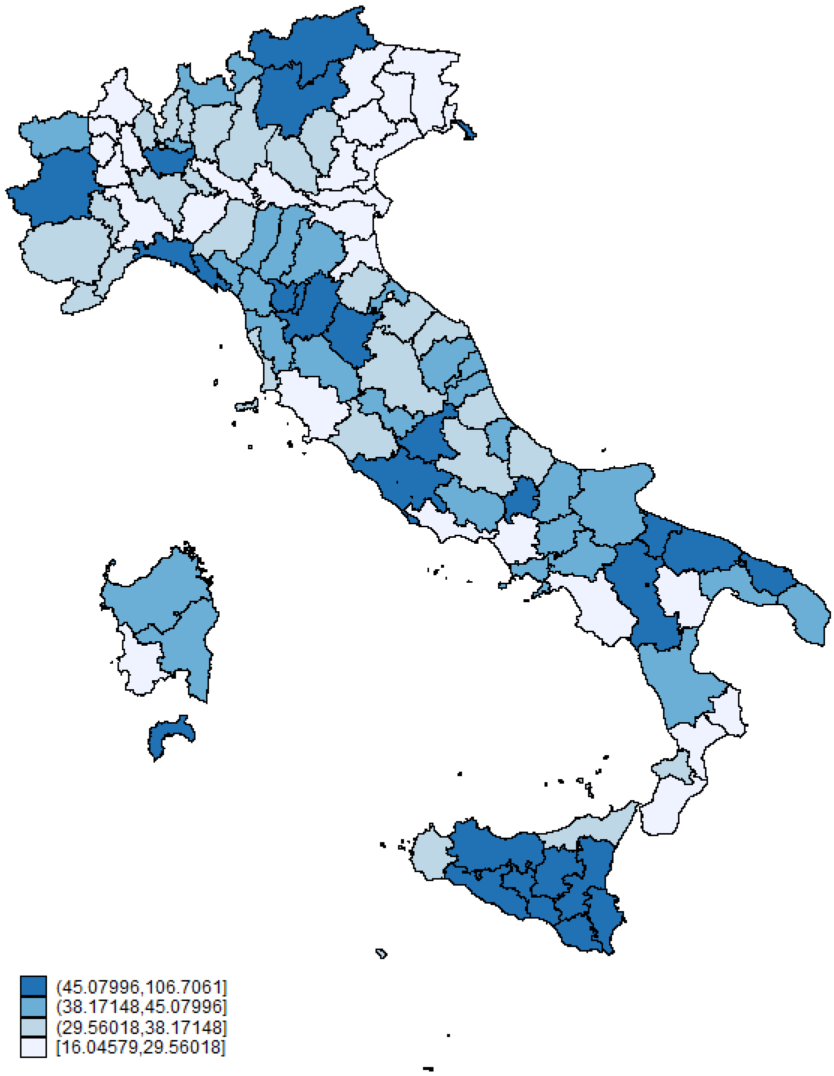
B Figures

Figure B1: Density of essential workers by province



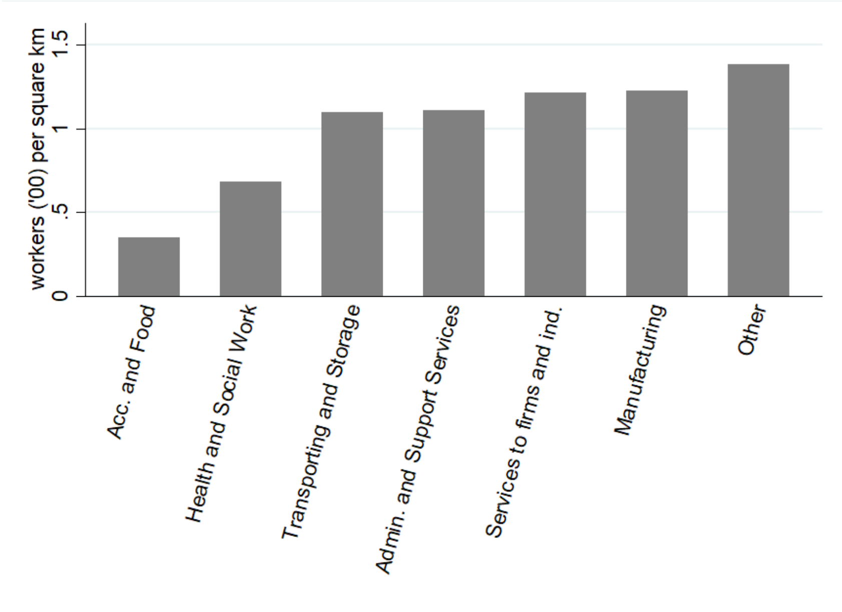
Note: 100 workers per built square kilometre in 2018 based on social security administrative data.

Figure B2: Population density by province



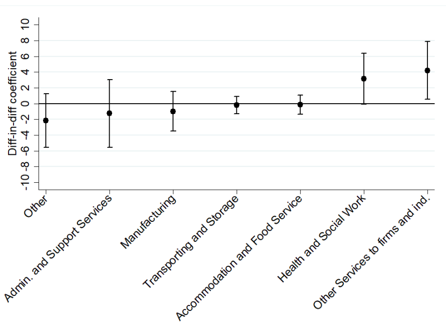
Note: 100 population per built square kilometre at the start of 2020 based National Statistical Institute data.

Figure B3: Average Density of Essential Sectors

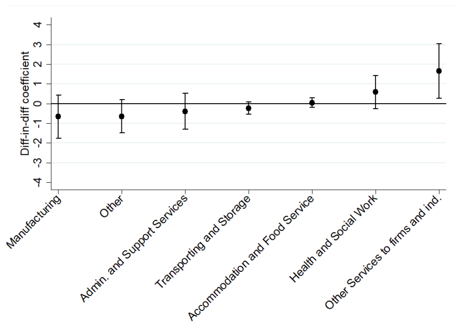


Note: Figure plots the average density of essential workers by sectors across Italian provinces. Density is measured as the number of workers in essential sectors (in hundreds) per built square kilometre. Data weighted by population in 2020. Services to firms and ind. includes: Financial and Insurance activities; Wholesale and Retail Trade; Professional, Scientific and Technical Activities. Other category includes: Agriculture, Forestry and Fishing; Water Supply; Sewerage, Waste Management and Remediation Activities; Other Service Activities; Construction; Electricity, Gas, Steam and Air Conditioning Supply; Information and Communication; Education; Public Administration and Defence; Compulsory Social Security; Mining and Quarrying.

Figure B4: Effect of density of essential sectors on Covid-19 infections and mortality by sector: coefficients



(a) Cases per 100,000 of population



(b) Deaths per 100,000 of population

Note: Estimates for the effect of density of essential workers in different sectors on Covid-19 infections and mortality. Density of workers in essential sectors is measured as the number of workers (in hundreds) employed in essential sectors in 2018 per built square kilometre. Panel (a) reports effects for the number of reported cases for 100,000 inhabitants while Panel (b) reports the effect on number of deaths per 100,000 inhabitants. The regression includes a 4th order polynomial trend from the first registered Covid-19 case in the province, and date and province fixed effects. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020. Observations weighted by the population in the province at the start of 2020. Confidence intervals at 95% based on standard errors clustered at province level reported. Services to firms and ind. includes: Financial and Insurance activities; Wholesale and Retail Trade; Professional, Scientific and Technical Activities. Other category includes: Agriculture, Forestry and Fishing; Water Supply; Sewerage, Waste Management and Remediation Activities; Other Service Activities; Construction; Electricity, Gas, Steam and Air Conditioning Supply; Information and Communication; Education; Public Administration and Defence; Compulsory Social Security; Mining and Quarrying.

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The Centre for Economic Performance Publications Unit
Tel: +44 (0)20 7955 7673 Email info@cep.lse.ac.uk
Website: http://cep.lse.ac.uk Twitter: @CEP_LSE