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

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

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Abstract
This paper investigates the effect of the lockdown on COVID-19 infections. After the 22nd of March 2020, the Italian government shut down many economic activities to limit the contagion. Sectors deemed essentials for the economy were, however, allowed to remain active. 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 an additional daily registered case per 100,000 inhabitants. This is a sizeable impact, and it represents about 18% of the daily increase in COVID-19 cases after the 22nd of March. Back of envelope computations suggest that the about one third of the cases considered could be attributed to the less stringent lockdown for essential sectors, with an additional 107 million Euros in direct expenditure. Although this assessment should be taken with caution, this suggests that the less stringent lockdown came at moderate public health related economic costs. In addition, we find that these effects are heterogeneous across sectors, with services having a much larger impact than Manufacturing, while there are only small differences across geographic areas. These results are stable across a wide range of specifications and robustness check.

JEL classification: J18, I18.

Keywords: COVID-19, lockdown, essential sectors

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1 Introduction

The spread of the COVID-19 represents one of the most challenging health and economic crises the world has experienced in the recent past. Starting from China, the virus appeared in most developed countries and in many developing ones, with enormous life and economic costs. Government around the world implemented a mix of non-pharmaceuticals interventions, in order to contain the spread of the disease and its health costs. Social distancing and lockdown measures 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 situation.

In many countries, governments imposed strong limitations to circulations of people. While social distancing measures de facto implied a stop to several sectors (i.e restaurants, pubs, hairdresser etc), in some cases, restrictions were explicitly extended to many productive activities. 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 at the height of the epidemic, to limit the circulation of workers. This had important economic costs and determined a heated debate between businesses and legislators (Wong 2020).

While deciding which level of restrictions to impose, governments faced a trade-off between containing the pace of infection and avoiding the collapse of the economy. Despite the crucial importance of this question from a public policy perspective, the assessment of these interventions has so far received limited attention in empirical studies. In this work, we contribute to frame this problem by estimating the cost of allowing a partial continuation of the economic activity in terms of additional reported infections. 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. We find that a higher density of essential workers led to higher number of local contagions with about 0.25 additional daily cases per 100,000 inhabitants for one hundred workers in essential sector per built square kilometre. This is a sizeable impact, and a standard deviation change in this density corresponds to about

18% of the average number of new cases in the period after the implementation of the lockdown. 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. The estimated direct economic costs for the National Health system correspond to about an additional 107 million Euros, which suggests moderate public health related economic costs. This assessment, however, does not consider many additional aspects of the consequences for the government budget and overall health expenditure, and they should be taken with caution. Additionally, we show that not all economic activities contribute equally: 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. This is informative for the current policy debate and it suggests possible directions for future action.

These results are robust to a wide range of identification and robustness checks. We exclude that results are driven by local time varying policies with region by date fixed effects, or by specific geographic area. Results do not seem to be related to breaks in other variables, which might be correlated with our variable of interest, and are consistent with a different measure of density of essential workers. Moreover, provinces with different density of essential workers do not show differential trends prior to the introduction of the policy, which supports our identification strategy.

This work contributes to a small but 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. Ferguson et al. (2020) develop a transmission models of different non-pharmaceutical interventions and suggest that a mix of suppression policies are more likely to be effective in facing the pandemic, rather than mitigation measures. Acemoglu et al. (2020) use a heterogenous agent SIR model and conclude that a lockdown concentrated on at risk groups is likely to be the most effective way to both contain the epidemic and limit economic losses. Greenstone and Nigam (2020) provide a money evaluation of the effect of the social distancing measures in the US showing that there are substantial monetary gains from reduced mortality. Fewer works investigate empirically the role of public policies to contain the contagion. Hatchett et al. (2007) use historical data on a mix of policy responses in US cities to the Spanish flu outbreak. They find that a mix of early policy interventions led to lower peak excess mortality but to less precise differences in overall contagions and mortality, as the disease was more likely to reappear when interventions were lifted. Fang et al. (2020) use a spatial difference-in-difference framework and investigate the effectiveness of mobility restrictions in reducing the number of novel infections in China after the Wuhan lockdown. Hsiang et al. (2020) compile a rich cross-country dataset on COVID-19 policies and use regression analysis to assess their role in containing the pandemic. Their estimates suggest that policy response prevented about 60 million of cases throughout China, South Korea, Iran, Italy, France, and the United States. Dave et al. (2020) study the effect of shelter in place policies across US states, and find that they reduced mobility and reported infections, while a negative effect on mortality was imprecisely estimated. Friedson et al. (2020) investigate the impact of California stay at home policy in a synthetic control framework and estimate that, although the intervention reduced mortality, this came at a high economic cost, with about 400 job losses for each less fatality. 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, we provide among the first estimates of the effect of a partial lockdown on the spread of the COVID-19 contagions. 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.

First, we obtain the number of COVID-19 cases for the 106 Italian provinces from the Civil Protection website. This includes not only those individuals who are ill at a specific point in time but also individuals who dies or contracted the disease in the past and, eventually, either died or recovered. 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. We also get information on the numbers of tests at regional level (NUTS 2), as well as deceased and healed patients. The first information is particularly salient as it allows to capture possible increases in positive cases due to a higher frequency of tests rather than infections. 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 true number of positive individuals as, in many cases, the disease was asymptomatic or with minor symptoms. The number of reported cases, however, is likely to reasonably capture the most severe cases, which are relevant from a health analysis perspective. The use of reported infections rather than mortality has the further advantage of isolating more precisely the action of the policy on the disease: indeed, the lockdown might affect mortality through other channels such as traffic fatalities (Oguzoglu 2020) or higher mortality for other disease, which are treated with delay due to the pandemic emergency (Al-Quteimat and Amer 2020). For this reason, we believe that registered cases are an important outcome with respect to the evaluation of lockdown.

Then, we combine this information with rich administrative data on the universe of private non-agricultural employees from Italian Social Security. 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.[1] 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]

Table 1 reports summary statistics for our main variables of analysis. Both variables show a substantial variability. The change in the number of positive cases is extremely variable, which reflects both the evolution of the epidemics over time, and the great differences of the number of the contagion across provinces. The distribution of the density of workers in essential sectors also shows a relevant variability although most of the provinces are between 200 and 500 workers per built square kilometre. 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 sector considered essential. Both these elements contribute to determine the apparently large number reported. For more information on the geographic distribution of the density of essential workers, we remand to Figure B1 in the Appendix. The density appears to be higher in the northern part of Italy but there are also areas in the South which show a similar level of density. We perform robustness checks to assess the resilience of the estimates to the exclusion of specific areas, and results are stable.

[1]Preliminary data for 2019 provide very similar measures.

[2]We provide a sensitivity of the estimates to changes in the definition of this variable in Table 3. Results are 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.

3 Methods

The increase in COVID-19 diffusion during February and early March 2020 led the Italian government to take decisive steps 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 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, which strongly limited economic activity. More specifically, the law ordered an immediate suspension of all commercial and industrial activities, but for "essential" sectors (see Table A2 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 and in line with recent recommendations (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). We estimate the following equation:

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

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 a rich number of possible confounding factors such as 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. Trends start from the first day of positive case of COVID-19 case in the province to take into account 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 to obtain nationally representative estimates.

Our policy setting provides several advantages in terms of identification. First, the policy was implemented in isolation with other measures, and regional authorities did not play a major role in establishing additional measures to fight the pandemic. Second, the policy was implemented nationwide, so it is unlikely to be correlated both in its timing and intensity with our main variable of interest, that is the density of essential workers. A few measures were introduced before the 22$^{\text{nd}}$ of March at local level. These measures were initially 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 (1$^{\text{st}}$ of March), but they were soon extended to the whole national territory (8th of March). In short, additional interventions targeting specific areas were generally short lived and milder with respect to the later nationwide lockdown. Results are quantitatively consistent if these regions are excluded. 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 in our estimates as local contagion is then diffused to other areas. First, it is important to notice that mobility to different municipalities was heavily restricted, and individuals could leave their municipality only for undelayable work, health, or emergency reasons. Commuting for work in this sense might be problematic. Italian workers show a substantial mobility for work reasons. and about 50% of workers moved to a different municipality to work in 2017 (based on reports from the National Statistical Institute; ISTAT 2018). However, this mobility tends to be relatively local: almost 80% of these workers remained in the same province. Consequently, our level of geographic aggregation reduces the possibility of downward bias in our estimates.

4 Results

The different exposure to essential industries had an important impact on the number of positive 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 estimates decline to about 0.25 once fixed effects are included in Column (2), and they remain 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 essentials: this would imply about an additional case per day per 100,000 inhabitants, which corresponds to about 18.7% of the average number of daily cases in the period after the policy implementation. Regional controls for number of tests only mildly affect the coefficient as reported in Column (3). In all these cases, this effect is highly statistically significant (p-value<0.01). Column (4) includes daily fixed effects interacted with 20 regional fixed effects. Hence, in this latter specification, we exploit 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 margins in its management. These fixed effects allow us to take into account 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. Finally, in Column (5), 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 suggests that the lockdown measures show relevant benefits at any point during the pandemic and are beneficial under different health and social backgrounds.

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 take into account the density of workers from 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.[4] 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 respective 95% confidence interval in Figure 1.[5] The Figure points at a strong heterogeneity across sectors: while manufacturing workers seem to have no impact on the contagion, other sectors such as health and social work and other services to firms and individuals[6] played a much more relevant role. A standard deviation change in "Other Services to firms and individuals" leads to about 5 daily additional cases per 100,000. The more direct interaction with both co-workers and clients, without the protective precautions of the

[4] For the relative contribution of each sector to the overall density see Figure B2 in the Appendix

[5] For the raw coefficient see Figure B3 in the Appendix

[6] 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.

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.

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 22^{nd} 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 (22^{nd} of March to 4^{th} 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 22^{nd} of March and the 5^{th} 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. 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.[7] 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, according to 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 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 beyond

[7]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.

the scope of the current study, and we leave it for future research.

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:

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

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 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.

Then, we move to validate our estimates. To do so, we perform a battery of robustness checks, and report the results in Table 3. We report our baseline result, Column (2) 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 22^{nd} period. If the observed pattern in the data is indeed related to other trends related to other observables, 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. 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. 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). Finally, we exclude population weights in Column (10), which leads only to negligible variations in our estimates.

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. 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 institutional similarities with other developed economies 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 new contagions: an additional 100 workers per square kilometre in essential sectors lead to an about 0.25 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. This result is quantitatively important. The implied 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 likely to be a lower bound and should be anyway taken with care. We also show that this effect is quite stable across geographic areas, suggesting that locking down even if at different stages of the contagion it is always advisable, moreover, the average effect hides a strong sectoral heterogeneity. Essential services show a much larger impact than manufacturing, which suggests that the extension of the lockdown to these activities might have had a limited impact on the pandemic with, at the same time, important economic costs. The data do not show marked differences in the effect of the policy across geographic areas. The dynamic of new contagions was similar in provinces with different exposure to these sectors before the passing of the legislation, which provides evidence of the lack of difference in pre trends and supports our identification assumption. 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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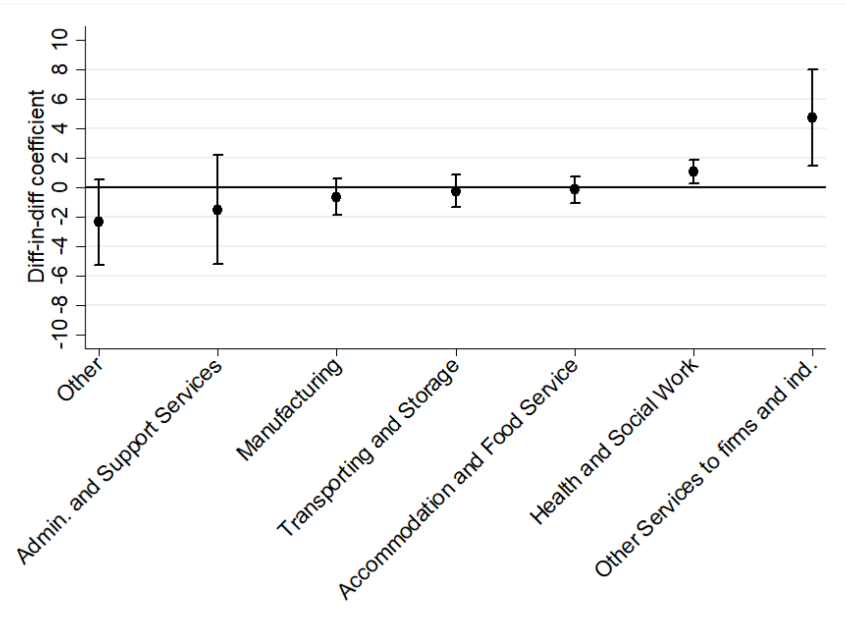
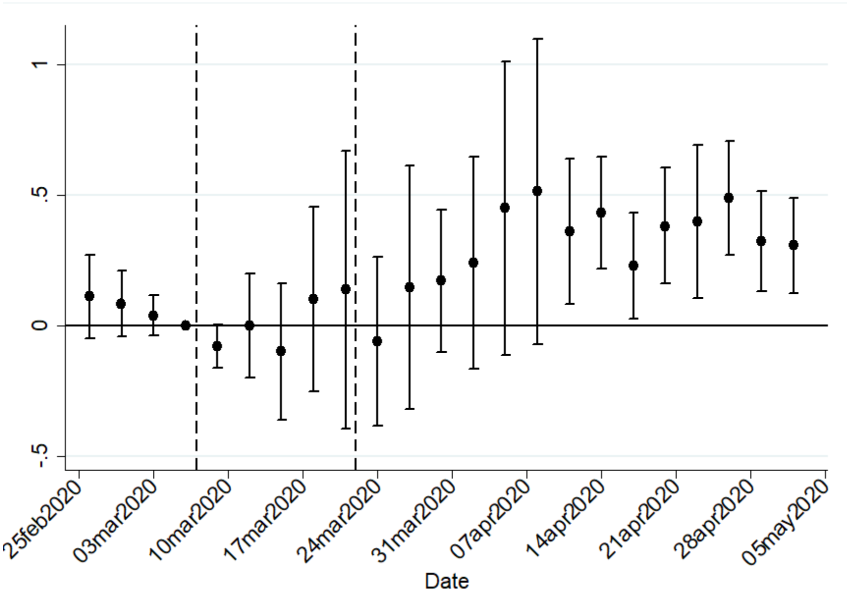
Figures

Figure 1: Effect of density of essential workers by sector



Note: Estimates for difference in difference coefficients of density of essential workers in different sectors. 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. 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



Note: Estimates for coefficients of density of essential workers before and after the policy implementation as described in Equation 2. 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 5th and the 7th of March is used as a reference period. Confidence intervals at 95% based on standard errors clustered at province level reported. Regression based on daily data for 106 Italian provinces between the 25th of February and the 4th of May 2020.

Tables

Table 1: Summary statistics for main variables

	Daily change COVID-19 cases per 100,000 inhabitants	100 essential workers per built square km
Mean	5.012	7.052
Standard deviation	7.397	4.178
Minimum	0.000	2.242
25ht percentile	0.451	4.351
50ht percentile	2.074	5.704
75ht percentile	7.031	8.184
Maximum	94.998	22.492

Note: Daily change in confirmed COVID-19 cases based on Civil Protection records per 100,000 inhabitants at 1st of January 2019 from National Statistical Institute (ISTAT) sources. Number of workers in essential sectors obtained from Social Security archive and normalized by built area in square kilometre at province level. Data weighted by province population at 1st of January 2019.

Table 2: Effect of density of essential sectors on change in number of new daily COVID-19 cases

VARIABLES	(1)	(2)	(3)	(4)	(5)
Ess. per Km2 X post 03/22	0.421***	0.266***	0.239***	0.297**	0.249***
	(0.071)	(0.075)	(0.079)	(0.130)	(0.070)
Ess. per Km2 X post 03/22 X Centre					-0.001
					(0.125)
Ess. per Km2 X post 03/22 X South					-0.099
					(0.099)
Observations	7,314	7,314	7,314	7,245	7,314
R-squared	0.166	0.533	0.540	0.715	0.540
SD Essential	4.2	4.2	4.2	4.2	4.2
Province FE	YES	YES	YES	YES	YES
Date FE	YES	YES	YES	YES	YES
Ep. Trend 4th	NO	YES	YES	YES	YES
Reg. Controls	NO	NO	YES	NO	NO
RegionXDate FE	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 change in 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 change in the 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 2019. Standard errors clustered at province level reported in parenthesis. Level of significance: ***, 0.01; **, 0.05; *, 0.1.

Table 3: Effect of partial lockdown of essential sectors on change in number of new daily COVID-19 cases

VARIABLES	(1)	(2) No Lombardy and Piedmont	(3) No Week Ends	(4)	(5)	(6)	(7)	(8) No Health	(9)	(10) No Weights
Ess. per Km2 X post 03/22	0.266***	0.273***	0.236***	0.359***	0.238***	0.265***	0.237***			0.252***
	(0.075)	(0.088)	(0.076)	(0.087)	(0.064)	(0.067)	(0.067)			(0.087)
Population per Km2 X post 03/22				-0.029						
				(0.022)						
% Above 65 X post 03/22					0.561***					
					(0.156)					
% below 12 X post 03/22						-1.256***				
						(0.440)				
Average Age X post 03/22							0.758***			
							(0.218)			
Ess. (no health) per Km2 X post 03/22								0.283***		
								(0.082)		
# Ess. workers per 100 inhab. X post 03/22									0.192***	
									(0.050)	
Observations	7,314	5,934	5,194	7,314	7,314	7,314	7,314	7,314	7,314	7,314
R-squared	0.533	0.499	0.537	0.533	0.541	0.537	0.539	0.533	0.531	0.497
SD Essential	4.2	3.98	4.2	4.2	4.2	4.2	4.2	3.93	5.4	3.24
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Date FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ep. Trend 4th	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 change in 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 change in the number of tests, healed and deceased patients in the region. Observations weighted by inhabitants on the 1st of January 2019. 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. 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

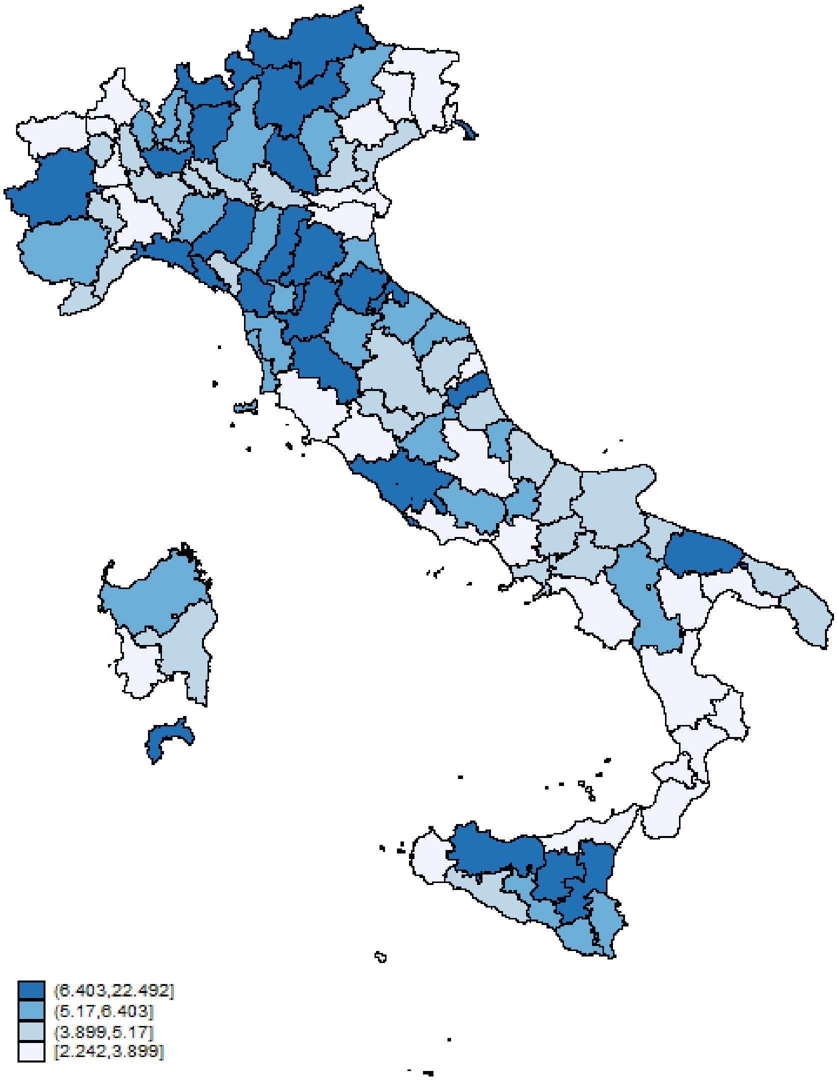
ATECO CODE	LABEL
1	Agriculture and animal products
3	Fishing
5	Coal mining
6	Oil and Gas extraction
9.1	Support for oil and gas extraction
10	Food industry
11	Beverage industry
13.96.20	Technical textile and industrial products production
13.95	Textile excluding clothing
14.12.00	Work clothing production
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

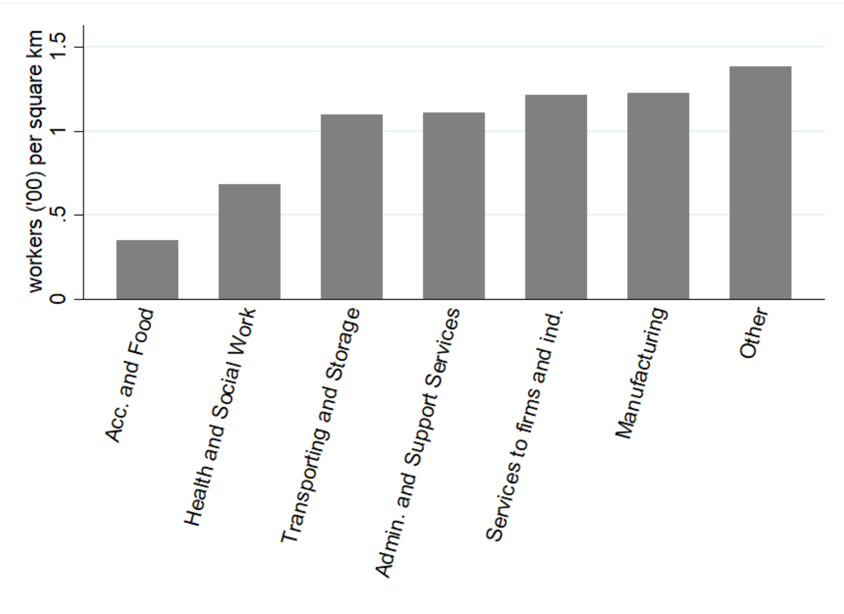
B Figures

Figure B1: Density of essential workers by province



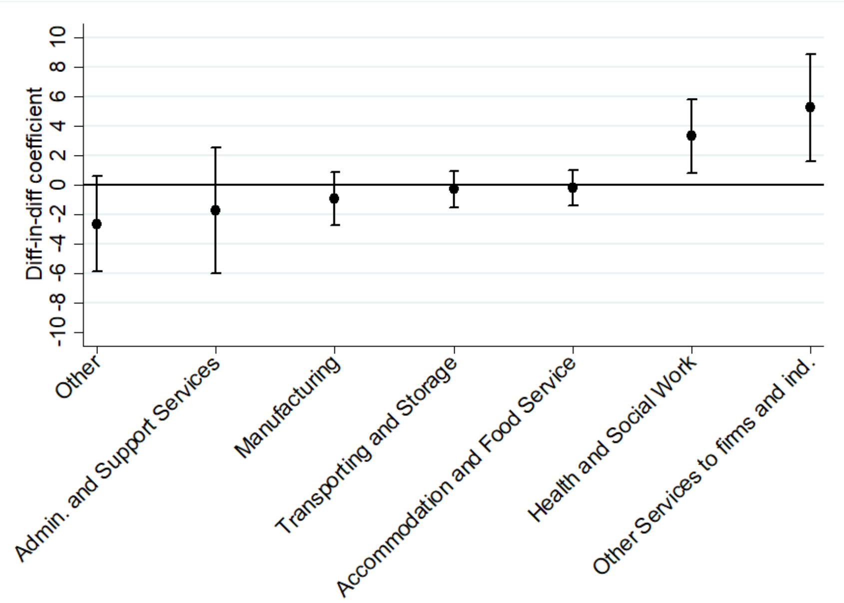
Note: 100 workers per built square kilometre based on 2018 social security administrative data.

Figure B2: Average Density of Essential Sectors



Note: Figure plots the average density of essential workers by sectors across Italian provinces. Data weighted by population in 2019.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 B3: Effect of density of essential workers by sectors



Note: Estimates for difference in difference coefficients of density of essential workers in different sectors. 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. 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.