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When and how do business shutdowns work? Evidence from Italy's first COVID-19 wave

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WHEN AND HOW DO BUSINESS SHUTDOWNS WORK? EVIDENCE FROM ITALY'S FIRST COVID-19 WAVE

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ABSTRACT/ RESUME

When and How Do Business Shutdowns Work? Evidence from Italy's First COVID-19 Wave

Governments around the world have adopted unprecedented policies to deal with COVID-19. This paper zooms in on business shutdowns and investigates their effectiveness in reducing mortality. We leverage highly granular death registry data for almost 5,000 Italian municipalities in a diff-in-diff approach that allows us to mitigate endogeneity concerns credibly. Our results, which are robust to controlling for a host of co-factors, offer strong evidence that business shutdowns are very effective in reducing mortality. We calculate that the death toll from the first wave of COVID-19 in Italy may have been about twice as high in their absence. Our findings also highlight that timeliness is key – by acting one week earlier, the death toll may have been reduced by up to an additional 25%. Finally, shutdowns should be targeted. Closing service activities with a high degree of interpersonal contact saves the most lives. Shutting down production activities – while substantially reducing mobility – only has mild effects on mortality.

JEL classification codes: E02, E25, E63, J31, J61

Keywords: COVID-19, business shutdowns, Italy, mortality

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Est-ce que les fermetures d'entreprises sont efficaces pour réduire le nombre de décès liés à la COVID-19? Evidence de la première vague du virus en Italie

Partout dans le monde, les authorités gouvernementales ont adopté des politiques sans précedent pour lutter contre la COVID-19. Cet article se concentre sur les fermetures d'entreprises et examine son efficacité dans la reduction du nombre de décès liés au virus. Nous utilisons des données sur la mortalité très granulaires, couvrant plus de 5,000 municipalités italiennes, dans une approche *diff-in-diff* qui nous permet de atténuer avec crédibilité les potentiels problèmes d'endogénéité. Nos résultats, robustes même après le controlle d'une multitude de cofacteurs, montrent clairement que les fermetures d'entreprises sont très efficaces pour réduire la mortalité. Nous calculons que le nombre de décès de la première vague de la COVID-19 en Italie aurait été le double en leur absence. Nos résultats soulignent également que la célérité est un facteur essentiel pour le succès de ces mesures - en agissant une semaine plus tôt, le gouvernement aurait pu réduire le nombre de décès d'un 25% supplémentaire. Nos estimations suggèrent que les fermetures doivent être ciblées: la fermeture des magasins, des bars et des restaurants sauve le plus grand nombre de vies, tandis que l'arrêt des activités de l'industrie manufacturière n'a que des effets modérés.

Classification JEL: E02, E25, E63, J31, J61

Mots Clés: COVID-19, fermetures d'entreprises, Italie, mortalité

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When and How Do Business Shutdowns Work? Evidence from Italy's First COVID-19 Wave

By Gabriele Ciminelli and Sílvia Garcia-Mandicó[1]

1. Introduction

1. The sudden appearance of COVID-19 in early 2020 has forced many governments worldwide to implement hastily arranged policies to limit the death toll from the virus, including travel restrictions, lockdowns, and business shutdowns. These measures aim to save lives by reducing the rate of new infections – "flattening the curve" – thus preventing the congestion of the health care system and ensuring that there is enough capacity to admit everyone in need (Ferguson et al., 2020[1]). In this paper, we investigate the effectiveness of business shutdowns, focusing on three issues in particular. First, we assess the overall effects of business shutdowns in reducing mortality. Second, we focus on the importance of timing – that is, when in the epidemic curve they are most effective (the when). Third, we explore how the effectiveness of business shutdowns varies depending on which particular sector of the economy is closed down (the how).

2. To carry out the analysis, we focus on the first wave of COVID-19 in Italy, for long one of the world's worst affected areas. Focusing on Italy has two main advantages. The first is that the Italian government implemented a very strict business shutdown policy, affecting nearly every aspect of economic

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activity. This allows us to investigate the effectiveness of shutdowns not only in the services sector but also in production activities. The second key advantage is the availability of highly granular daily death registry data, as well as data on socio-demographic, labour market and territorial characteristics, for thousands of municipalities. In particular, our dataset covers almost 5,000 municipalities and spans throughout the entire period of the first wave of the COVID-19 epidemic in Italy (February to May 2020). We use these data, which to our knowledge are unmatched in other countries, in a diff-in-diff approach à la Rajan & Zingales (1998[2]). We exploit a peculiarity in the implementation of the business shutdowns policy that allows us to mitigate endogeneity concerns credibly. Rather than targeting specific firms in specific communities, the government ordered the closure – throughout the country and at the same time – of all firms not operating in essential sectors. By calculating the employment share in non-essential sectors, we can isolate variation in the degree to which different communities were affected by the shutdowns. Because the government's list of essential sector was valid at the national level, such variation is exogenous to the policy itself.

3. Our results – which are robust to controlling for a host of risk factors – offer strong evidence that business shutdowns can be very effective in curbing COVID-19 mortality and more generally the spread of infectious diseases. Our first finding concerns their overall effectiveness. We estimate that a 10 percentage point higher share of employment in shutdown sectors is associated with 0.5 fewer deaths per day per 100,000 inhabitants. To put this in context, we use the coefficients that we estimate to quantify the number of lives saved through business shutdowns. We estimate that the death toll of the first wave of the COVID-19 epidemic in Italy could have been twice as high in absence of business shutdowns and the associated lockdown.

4. Our second set of results instead highlights the importance of timeliness. Exploiting the fact that communities were at different stages in the epidemic curve when business shutdowns were implemented – some had a high number of infections, while others had just a few – we estimate that “early” implementation increases the effectiveness of shutdowns. According to these results, up to an additional 25% of deaths may have been prevented if shutdowns had been ordered one week earlier when the cumulative caseload was about one third lower.

5. In a next step, we study how the effectiveness of business shutdowns varies depending on which particular sector is closed down. Our third finding is that closing down the hospitality sector has the largest effects in reducing mortality. Instead, shutting down manufacturing and other production activities – while substantially reducing mobility – has only limited effects on mortality rates. The higher effectiveness of the shutdowns of non-essential services relative to production activities is consistent with the notion that a higher degree of interpersonal contact at the workplace can facilitate the spread of infectious diseases (Dingel and Neiman, 2020[3]; Markowitz, Nesson and Robinson, 2019[4]; Lewandowski, 2020[5]). While in sectors such as retail trade and hospitality workers interact with customers and customers interact among themselves, interpersonal contact in production activities is generally limited to workers in the same unit.

6. Our results on the heterogeneous effects of business shutdowns across sectors are related to those of Magnusson et al. (2020[6]) and Aron and Muellbauer (2020[7]), who explore COVID-19 infection and mortality differences by occupational exposure. The former match COVID-19 infection with occupational and demographic data for the full sample of the Norwegian working-age population. They find that nurses, physicians, dentists, physiotherapists, bus/tram, taxi drivers, bartenders, waiters, food service counter attendants and travel stewards – who typically have close contact with other people – had 1.5 to 4 times the odds of catching COVID-19 when compared to everyone in their working age. Aron and Muellbauer (2020[7]), instead, summarise excess deaths by occupation in England, highlighting that most of COVID-19 deaths were among people employed in the consumer-facing service sector.

7. Our findings and those of the studies reviewed above speak to a quickly growing literature that uses epidemiological models (such as SIR and SEIR) to assess how mitigation policies can be optimally set to minimize the burden on the economy while reducing the number of fatalities (Atkeson, 2020[8];

Eichenbaum, Rebelo and Trabandt, 2020[9]; Jones, Philippon and Venkateswaran, 2020[10]). To ensure tractability, SIR and SEIR models typically assume an equal number of contacts for each individual (Khain, 2020[11]).[2] Our results and those reviewed above show that this assumption may be problematic when determining optimal business shutdown policies.

8. We also contribute to a broader literature quantifying the effectiveness of social distancing policies on slowing the spread of infectious diseases. A large part of this literature has focused on evaluating the effects of lockdowns and travel restrictions on contagion and, ultimately, mortality (Adda, 2016[12]; Becchetti et al., 2020[13]; Chinazzi et al., 2020[14]; Égert et al., 2020[15]; Fang, Wang and Yang, 2020[16]; Juranek and Zoutman, 2020[17]; Pedersen and Meneghini, 2020[18]; Dave et al., 2020[19]). In particular, Song et al. (2021[20]) and Courtemanche et al. (2020[21]) estimate the impact of government-imposed closures of some non-essential businesses on the spread of COVID-19 in the U.S. Their focus is on restaurants, bars, and entertainment-related businesses. Our focus is instead on the effects of generalised businesses shutdowns, a relatively isolated and strict approach taken by the Italian government to curb COVID-19 infections. The case of Italy is also studied by Bongaerts, Mazzola and Wagner (2020[22]). Considering a subsample of municipalities and a much shorter timeframe, these authors also conclude that business shutdowns were very effective in reducing mortality but they do not explore the importance of timely interventions nor sectoral heterogeneity.

9. Finally, our paper is related to that of Aron and Muellbauer (2020[7]) and a plethora of other studies that rely on the concept of excess deaths – the difference between deaths for all causes during the COVID-19 epidemic and deaths that would be expected under normal circumstances – to estimate the mortality effects of COVID-19. The reason for considering excess deaths is that official data on COVID-19 fatalities may undercount the true number of deaths. As we show in a companion paper (Ciminelli and Garcia-Mandicó, 2020[23]), this appears to have been particularly relevant during the first months of the pandemic. Therefore, using official data to estimate the effectiveness of business shutdowns could bias our estimates. The downside of relying on excess deaths is that these do not strictly measure COVID-19 fatalities. To gauge COVID-19 fatalities through official death registry data, one would need to take into account how deaths due to causes other than COVID-19 evolved during the pandemic period relative to earlier years. Since we cannot do this with the data that we have available, in the rest of the paper we analyse overall excess mortality during the pandemic and loosely refer to it as COVID-19 mortality.

10. The rest of the paper is organised as follows: Section 2 describes the dataset and presents the empirical methodology. Section 3 presents our baseline results on the overall effectiveness of business shutdowns, discusses a battery of robustness checks and illustrates the back-of-the-envelope calculations that we perform to gauge the number of lives saved through the shutdowns. Section 4 extends the analysis to the timing of shutdowns and the heterogeneity of their effectiveness across sectors. Section 5 concludes.

2. Dataset and Methodology

2.1. Death registry data

11. Any empirical study on the effectiveness of COVID-19 mitigation and/or suppression policies needs to deal with the issue of how to measure COVID-19 mortality. At first glance, using official fatality data provided by the authorities may appear as the most natural choice. However, these data suffer from serious undercounting issues and thus risk understating the true extent of COVID-19 outbreaks (Ciminelli and Garcia-Mandicó, 2020[23]). Therefore, we rely on the concept of excess deaths – that is, the difference between deaths for all causes during the COVID-19 epidemic and deaths that would be expected under

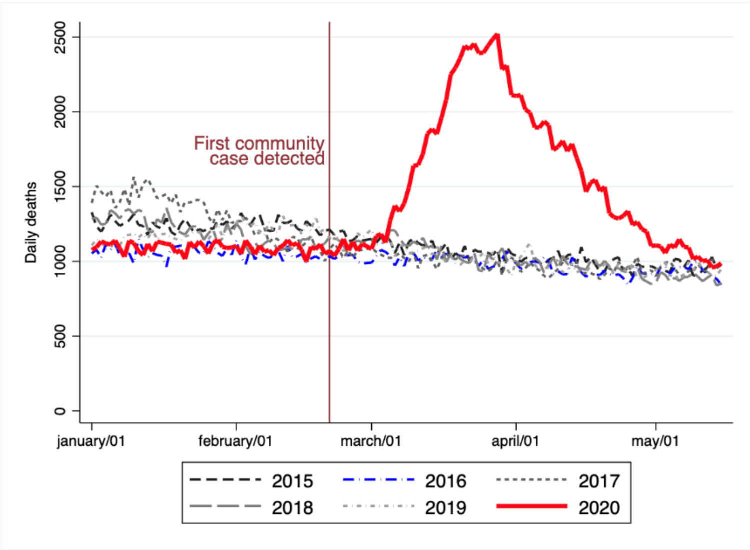
[2] An exception is the work of Kaplan, Moll and Violante (2020[43]). These authors incorporate heterogeneity in contact by sector, which allow them to discuss the need for sector-specific policies.

normal circumstances. As explained above, this measure does not allow uncovering the COVID-19 fatality rate, but rather pools together direct and indirect COVID-19 deaths.[3] Since our focus is not narrowly on the COVID-19 fatality rate, that is not a drawback in our context. Moreover, focusing on excess deaths has the key advantage that underlining data are much more granular than official fatality data, which is crucial for our identification strategy, as it will become clear in Section 2.3 below.

12. We source death registry data from ISTAT (2020[24]). The data provide municipality-level information on daily deaths for the January/1st to May/15th period, from 2015 to 2020 for all Italian municipalities. Since Italy's first wave of COVID-19 mostly affected the northern part of the country, while leaving the central and southern parts largely unscathed, we focus on the ten most northern regions (Emilia-Romagna, Friuli-Venezia Giulia, Liguria, Lombardy, Marche, Piedmont, Toscana, Trentino-Alto Adige, Valle d'Aosta, and Veneto). These make up almost 60% of Italy's population and 95% of its fatalities during the first wave of COVID-19. The data cover 4,895 municipalities, accounting all of the local population in the ten regions that we consider. Annex Table A.1. provides more descriptive statistics.

13. Figure 1 below takes a first look at the data. Particularly, it compares daily deaths in 2020 (red solid line) to deaths in the five preceding years in the ten regions considered. Deaths in 2020 exhibit quite similar trends to deaths in 2016 (blue dashed line), up to the day in which Italy's first community case was detected (February/21st, vertical maroon line). The subsequent increase is exponential. At their peak, roughly a month after the first detection, daily deaths in 2020 are about two and a half times those in 2016, underscoring the severe effects of COVID-19 on mortality. After the peak, they gradually decline and return to normal levels around the end of our sample (mid-May). Our data thus cover the entire period of the first wave of COVID-19 in Italy.

Figure 1. Deaths in 2020 compared to the five previous years



Note: The figure compares daily deaths in 2020 (red solid line) to daily deaths in each of the five preceding years in the ten regions considered. The blue dashed line denotes deaths in 2016, which we use as counterfactual for the estimation of the effects of COVID-19 on mortality (see Section 2.4). The vertical maroon line denotes the day on which the first COVID-19 community case was detected, on February/21th).

Source: Authors' calculations based on ISTAT death registry data.

[3] Direct deaths refer to people dying of COVID-19, while indirect deaths refer to those dying for causes related to COVID-19, such as overcrowded hospitals. It should be noted, however, that COVID-19 may have also resulted in less deaths due to other causes, such as road accidents, accidents on the workplace and influenza. Hence, the number of indirect deaths is net of fewer deaths resulting from government social distancing policies.

2.2. Other data

14. The dataset is complemented with other variables that are needed to carry out the analysis. We start by sourcing census population data from ISTAT, which we use to construct the mortality rate series. These data provide information on the resident population in each municipality, as of January/1st, from 2015 to 2019. We impute 2020 population by using 2019 growth rates. We then turn to business shutdowns. As we discuss more in detail in Section 2.3 below, our empirical approach exploits heterogeneities in the extent that communities are affected by shutdowns. To measure such heterogeneities, we source municipality-level data on the number of workers (both employees and self-employed) in each 3-digit non-farm private sector, from ISTAT (2020[25]).[4] Since the government also ordered the closure of all educational institutions, we collect data on the number of residents enrolled at university from ISTAT (2020[25]) to run a robustness check.

15. We then source variables capturing slow-moving municipality characteristics that we use to control for potential co-factors of COVID-19 mortality. These characteristics broadly fall in three categories: (i) labour market characteristics, including the level of internal commuting and the employment rate; (ii) territorial characteristics, such as population density and the level of air pollution; and (iii) socio-demographic characteristics, including the share of females and that of high school graduates in the working age population, as well as the share of the elderly and mean income. We also construct a digital labour index measuring how much work is/can be done remotely in firms that are not affected by the shutdowns.[5] As most of these variables are not available at a regular frequency, we compute their means over the 2015-2019 period and treat them as time-invariant factors.

16. Finally, to estimate how business shutdowns impacted mobility, we source Google mobility report data. These data measure daily percent changes in mobility in different areas (workplaces, transit places, retail and recreation as well as residential places) from the 15th February 2020 onwards relative to the baseline 3rd January 2020-6th February 2020 for each Italian province. We construct local-labour-market-level variables using the share of people living in different provinces within each local labour market as weights. Annex Table A.2 provides information on sources and coverage.

2.3. Construction of the business shutdowns variable

17. The Italian government took unprecedented measures to fight the first wave of the COVID-19 epidemic in 2020. Twelve days after the first community case was identified, it ordered all educational institutions to close down and switch to online learning (March/5th). Less than a week later, it introduced a nationwide lockdown and ordered the closure of all non-essential commercial activities, such as shops, bars and restaurants (March/11th). About 10 days later, it compounded those measures by shutting down all non-essential production activities (March/22nd).[6] As the situation gradually improved, the government lifted the lockdown and allowed most businesses to reopen after almost two months of restrictions (May/4th).

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[4] We exclude agriculture and public administration from the analysis since data on the number of workers in these two sectors are not available at the municipality-level.

[5] To construct the index we use data on the number of employees in each sector from ISTAT (2020[25]) as well as sector-specific scores in the propensity towards digital labour. Such scores are assigned by Manyika et al. (2015[33]) and are reported in Table 4. The index is constructed computing the weighted sum of employment in sectors that stayed open, using the scores of Manyika et al. (2015[33]) as weights, and dividing it by the overall employment level (in open sectors). For the definition of open sectors, we rely on the list issued by the government (see Section 2.3 below for more details). Using the scores of Dingel and Neiman (2020[3]) leads to a very similar series.

[6] A few exceptions were granted. Restaurants could offer delivery, while non-essential production activities were allowed to operate if they were supplying goods to firms in essential sectors.

18. Our focus is on business shutdowns. Did they contribute to reducing mortality? If so, by how much? To answer these questions, we exploit variation across communities in the employment share in firms that were forced to shut down, which, crucially, is exogenous to the government policies. Exogeneity follows from the fact that, rather than targeting specific firms in specific communities, the government uniformly ordered the closure of all firms in certain specific sectors throughout the country. To do so, it issued a list of essential sectors valid countrywide: firms operating in those sectors could stay open, while all the others had to close down. Our identifying assumption is that business shutdowns were more binding in labour markets with a higher employment share in non-essential sectors (those in which firms had to shut down).

19. We therefore construct a variable measuring the employment share in firms affected by the shutdowns by matching the government's list of essential sectors to data on the number of workers in each non-farm private sector, sourced from ISTAT (2020[25]). Following common practice in spatial and urban economics studies (Moretti, 2010[26]; Acemoglu and Restrepo, 2020[27]; Allcott and Keniston, 2018[28]; Autor, Dorn and Hanson, 2013[29]), we pool municipalities into local labour markets. Essentially, these are areas whose borders are defined to minimise external commuting (commuting outside borders). Since in Italy many people work or study in a different municipality than the one in which they reside, carrying out the analysis at the local-labour-market-level limits possible mismatches between the extent to which individuals are affected by the government policies and the municipality where COVID-19 deaths are recorded. Overall, we follow 297 local labour markets, each with about 105,000 inhabitants on average.[7] Next, we calculate the number of workers in each sector affected by the government policies and construct our business shutdowns variable, BS_{it}, according to the following formula:[8]

$$BS_{it} = C_t * \frac{S_i^C}{E_i} + P_t * \frac{S_i^P}{E_i} \tag{1}$$

where ${S^C}_i$ (${S^P}_i$) measures the number of workers in commercial (production) firms affected by the shutdown of non-essential activities; E_i is total (non-farm) private employment; and C_t (P_t) is a commercial (production) activities shutdown policy dummy that takes value equal to 1 from 15 days after the introduction of the policy to 15 days after its expiration, where the 15-day lag is to account for the well-known time elapsing between COVID-19 infection and death (Lauer et al., 2020[30]; Linton et al., 2020[31]; SARS-CoV-2 Surveillance Group, 2020[32]).[9]

20. Our business shutdowns variable accounts for the fact that commercial and production activities were affected at different times and thus it is time-varying. When non-essential commercial and production activities were shut, about 50% of all non-farm private sector workers were forced to stay home, on

[7] To pool municipalities into local labour markets we use the 2011 concordance table provided by ISTAT. Except if otherwise specified, all the variables that we collect are at the municipality-level. We compute their local labour market equivalent using the categorization by ISTAT.

[8] Data on the number of workers disaggregated at the level of the local labour market is only available at the 3-digit level, while the government defined the sectors that had to close down using the 5-digit classification. To construct our business shutdowns variable, we source country-level data on the number of workers in each 5-digit sector and construct a measure of the share of suspended employment in each 3-digit sector at the national level, which we then use to compute the employment share in shutdown sectors in each local labour market.

[9] Lauer et al. (2020[30]) and Linton et al. (2020[31]) study COVID-19 incubation and find a lag of about 5 days between infection and incubation. The SARS-CoV-2 Surveillance Group (2020[32]) follows a panel of COVID-19 deaths in Italy and finds a median time of 10 days between the onset of symptoms and death. In light of these studies, we account for a minimum lag of 15 days between the implementation of the policy and its effects, but our results do not depend on this particular choice (alternative estimates available upon request).

average. Importantly, there is large variation across local labour markets, with the standard deviation of the employment share in shutdown firms being about 9% (Annex Table A.2).

21. To carry out an extension to the baseline analysis, we also construct business shutdown variables that are specific to the different sectors of the economy. We divide the economy into nineteen broad sectors, following the NACE Rev 2 industry classification, and consider the different extent through which each sector was affected by the shutdowns. Annex Table A.3 reports relevant sector-specific statistics, such as the share in overall non-farm private employment, the employment share in shutdown firms and the propensity towards digital labour (Manyika et al., 2015[33]). The four largest sectors – manufacturing, construction, hospitality and retail trade – are also among those most impacted by the shutdowns: together they account for about 60% of overall non-farm private employment, but they make up for almost 80% of employment in shutdown firms.

2.4. Empirical specifications

22. In this section, we describe our empirical methodology. We start by illustrating how we estimate the unconditional effects of COVID-19 on mortality, while we discuss how we investigate the effectiveness of business shutdown policies in reducing mortality further below. For the estimation, we opt for a differences-in-differences approach, using the year 2016 as counterfactual of what mortality would have been in absence of COVID-19. This gives us a measure of excess deaths from COVID-19. The choice of using mortality in 2016 as counterfactual follows from a visual inspection of the data (see Figure 1 above and Annex Figure A.1) and is also confirmed when using the synthetic control group method of Abadie et al. (2020[34]) and Abadie, Diamond and Hainmueller (2010[35]), which assigns unit weight to the year 2016.[10] We normalise the within-year time dimension *t* to take value equal to 0 on the day in which the first community case was detected (February/21st) and negative (positive) values on days before (after). We then estimate the mortality effects of COVID-19 over time through a flexible specification, as follows:

$$y_{ijt} = \delta d_j^{2020} + \sum_{t=-50}^{85} (\beta_t DAY_t * d_j^{2020} + \gamma_t DAY_t) + \mu_i + \varepsilon_{ijt} \quad (2)$$

where y_{ijt} measures daily deaths per 100,000 inhabitants in local labour market *i,* at within-year time *t*, for year *j*; d_j^{2020} is a dummy variable taking value equal to 1 in 2020 and 0 otherwise; DAY_t are within-year time effects, taking value 1 in each particular day of the year and 0 otherwise; μ_t are local labour markets fixed effects; and ε_{ijt} is an idiosyncratic error, clustered at the local labour market level. The coefficients of interest are the βs, which capture the effect of COVID-19 on the mortality rate at time *t.* For the estimation, we use the least-squares method with population analytical weights.[11]

23. The identification of our model relies on the validity of the *parallel trends assumption* in mortality in the treatment and counterfactual periods. We confirm the validity of this assumption in Annex Figure A.2. We also show that our estimates are robust to using a different counterfactual, such as the average deaths in the five preceding years (2015 to 2019) (also reported in Annex Figure A.2).

[10] However, our results are robust to other choices of counterfactual (Annex Figure A.2).

[11] We opt for population analytical weights due to the sensible differences in population size observed across local labour markets and because we will use the estimated coefficients to perform some back-of-the-envelope calculations on the overall mortality effects of COVID-19 (see Section 3.3 below). Our estimates are however robust to not weighting for population (results available upon request).

24. We next turn to business shutdowns. To estimate their effects on COVID-19 mortality, we extend Equation (2) by adding an interaction between the year 2020 dummy (d_j^{2020}) and the variable measuring the employment share in shutdown activities (BS_{it}). The specification that we estimate is as follows:

$$y_{ijt} = \delta d_j^{2020} + \sum_{t=-50}^{85} \left(\beta_t DAY_t * d_j^{2020} + \gamma_t DAY_t\right) + \lambda BS_{it} * d_j^{2020} + \sum_{t=-50}^{85} \pi_k \left(T_t * X_i^k * d_j^{2020}\right) + \mu_i + \varepsilon_{ijt} \quad (3)$$

where T_t is a COVID-19 treatment dummy, taking value equal to 1 in the period after the detection of the first community case and 0 in the period before; the X^ks are (time-invariant) local labour market characteristics included as controls; and the rest is as in Equation (2). The λ coefficient measures the effect of having a higher employment share in shutdown firms on the COVID-19 mortality rate. As before, we estimate Equation (3) through OLS with analytical population weights and standard errors clustered at the level of the local labour market.

3. Overall Effectiveness of Business Shutdowns in Reducing Mortality

3.1. Main results

25. Table 1 below reports the results on the effect of business shutdowns in reducing COVID-19 mortality. Column (1) shows estimates from a parsimonious model without control variables. Columns (2)-(6) show estimates from extended specifications in which we gradually add other demographic factors and labour market and territorial characteristics as additional controls. The reported coefficients measure the changes in daily deaths per 100,000 inhabitants associated with a standard deviation increase in the variable considered (about 10% in the case of the business shutdowns variable).

26. We estimate a negative and highly statistically significant coefficient for our business shutdowns variable across all specifications. A standard deviation higher employment share in shutdown firms is associated with about 0.45 to 0.7 fewer deaths per day per 100,000 inhabitants, depending on the specification considered. The coefficient is -0.5 in our most comprehensive specification including all controls, which we use as the baseline in the rest of the analysis (Column 6). Compared with an average daily death toll of about 1.5 deaths per 100,000 inhabitants, these results indicate that business shutdowns have quite meaningful effects in reducing mortality. We pin down these effects in Section 3.3 below, where we perform a back-of-the-envelope calculation on the overall number of deaths that have been prevented through these policies.

27. Turning to the control variables, they all enter with the expected sign and, except in one case, they are also highly statistically significant. A higher share of women in the working age population is by far the single most important factor reducing COVID-19 mortality. This is consistent with studies showing that women have a lower mortality from COVID-19 (SARS-CoV-2 Surveillance Group, 2020[32]). We also find a small, but not precisely estimated, mitigating role for education, proxied by the share of high school graduates.[12] Among risk factors, we control for population density and the level of air pollution. We estimate

[12] Education may affect health behaviour (Galama, Lleras-Muney and van Kippersluis, 2018[44]) and attitudes towards social-distancing practices (Adda, 2016[12]). Moreover, the level of education typically correlates with underlining health conditions (Case and Deaton, 2017[45]) and patients with co-morbidities tend to have a higher chance of dying from COVID-19 (Yang et al., 2020[46]). Unfortunately, data on health conditions at the municipality/local-labour-market-level are not available.

a positive and statistically significant coefficient for the former, confirming that closer interpersonal proximity facilitates the spread of COVID-19, while our results for the latter are in line with other studies suggesting that air pollution may increase the lethality of COVID-19 (Becchetti et al., 2021[36]).[13] Finally, our digital labour index measuring how much work can be done remotely in firms that stay open has a negative and highly significant coefficient, suggesting that remote working is associated with lower mortality.

Table 1. The effects of business shutdowns on COVID-19 mortality

	(1)	(2)	(3)	(4)	(5)	(6)
Business shutdowns	-0.44***	-0.61***	-0.69***	-0.54***	-0.47***	-0.52***
	(0.08)	(0.09)	(0.14)	(0.10)	(0.10)	(0.10)
Share working age females		-0.83***	-0.69***	-0.75***	-0.68***	-0.69***
		(0.18)	(0.16)	(0.16)	(0.16)	(0.15)
Share high school graduates			-0.22	-0.38**	-0.34*	-0.28
			(0.16)	(0.18)	(0.18)	(0.18)
Population density				0.29***	0.24***	0.32***
				(0.08)	(0.09)	(0.09)
Days PM10 above limit					0.25***	0.38***
					(0.08)	(0.10)
Digital labour in active firms						-0.43***
						(0.15)
Observations	80,487	80,487	80,487	80,487	80,487	80,487
R-squared	0.22	0.23	0.24	0.24	0.25	0.25

Note: The first row in this Table reports the effects of having a one-standard deviation higher employment share in non-essential activities. This is measured by the λ coefficient from Equation (3). Column (1) includes only the share of working age females as control variable, while columns (2)-(5) expand the specification to incorporate other control variables. Reported coefficients of control variables are normalised to measure the effect of a one standard deviation increase in the variable. The dependent variable is daily deaths per 100,000 inhabitants. All specifications include local labour market fixed effects, and are obtained using least squares with analytical population weights. Standard errors are clustered at the local labour market level.

Significance levels: * p<0.1, ** p<0.05, *** p<0.01.}

3.2. Robustness checks

28. Table 2 reports estimates from a battery of robustness checks on our baseline estimates. For ease of reference, Column 1 reports estimates from our baseline specification including all controls (as in Column 6 of Table 1 above). We start by focusing on an aspect of the construction of the business shutdowns variable. Although the government never formally ordered the shutdown of hotels, the accommodation sector was effectively shut since the introduction of the countrywide lockdown, as this severely restricted the movement of people and brought tourism to a halt. For this reason, in constructing the business shutdowns variable used in our baseline we also included the accommodation sector among shutdown commercial activities (the ${S^C}_i$ component in Equation 1 above). We estimate a specification in which we exclude the accommodation sector from the ${S^C}_i$ variable. The results are very similar to, and not statistically different from, our baseline (Column 2).

[13] Several studies have shown long-term exposure to particulate matters such as PM10 and PM2.5 to increase health risks (WHO, 2017[47]), while Wu et al. (2020[48]), Becchetti et al. (2020[13]) and Conticini, Frediani and Caro (2020[49]) have found a positive link between PM10 and COVID-19-induced mortality. Since data availability on air pollution is an issue, we use provincial-level data on the number of days in a year in which the level of PM10 is above the legal limit of $50mg/m^3$ and match it to local labour markets.

29. We also run two placebo tests to verify that our estimates are not the result of spurious relationships. In the first, we replace our policy intervention dummies C_t and P_t in Equation (1) with dummies taking value equal to 1 in the pre-policy period and equal to 0 otherwise. In the second, we instead assign random values to the ${S^C}_i$ and ${S^P}_i$ variables in Equation (1). Reassuringly, the new estimated coefficients are not statistically significant, suggesting that our baseline estimates are not spurious (Columns 3 and 4). Finally, we also check that our results do not suffer from omitted variable bias and add the employment rate, an index measuring the level of internal commuting, the share of residents enrolled at university, the share of people older than 80 and the mean income as additional controls.[14] The new estimates on the effects of business shutdowns are very close to, and not statistically different from, our baseline (Column 1).

Table 2. Robustness checks on the effects of business shutdowns on COVID-19 mortality

	(1)	(2)	(3)	(4)	(5)
Business shutdowns	-0.52***	-0.52***	-0.04	-0.05	-0.52***
	(0.10)	(0.12)	(0.16)	(0.54)	(0.13)
Share working age females	-0.69***	-0.69***	-0.72***	-0.72***	-0.62***
	(0.15)	(0.16)	(0.16)	(0.16)	(0.16)
Share high school graduates	-0.28	-0.30	-0.17	-0.16	-0.43**
	(0.18)	(0.19)	(0.16)	(0.16)	(0.18)
Population density	0.32***	0.31***	0.34***	0.34***	0.32***
	(0.09)	(0.09)	(0.10)	(0.10)	(0.11)
Days PM10 above limit	0.38***	0.37***	0.39***	0.40***	0.33***
	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)
Digital labour in active firms	-0.43***	-0.33**	-0.35**	-0.35**	-0.42**
	(0.15)	(0.15)	(0.15)	(0.15)	(0.19)
University closures					-0.01
					(0.02)
Employment rate					0.08
					(0.18)
Internal commuting index					0.27*
					(0.14)
Share of 80+					0.32**
					(0.15)
Mean income					0.12
					(0.15)
Observations	80,487	80,487	80,487	80,487	80,487
R-squared	0.25	0.25	0.25	0.25	0.25

Note: See notes to Table 1. Column (1) reports the baseline specification (Column 6 in Table 1). Column (2) excludes the accommodation sector, Columns (3) and (4) perform placebo tests, while Column (5) reports the results from including additional controls.

30. Individuals may have spontaneously changed their behaviours, for instance limiting their mobility, due to concerns over the spread of COVID-19 before the government ordered the closure of non-essential businesses and the associated people lockdown. If spontaneous changes in behaviour positively correlate

[14] Markowitz, Nesson and Robinson (2019[4]) have shown that higher employment rates are associated with a higher flu incidence, while Adda (2016[12]) and Harris (2020[50]) have shed light of the important role of commuting for the spread of infectious diseases. We therefore control for both these factors. We also account for the share of residents enrolled at university to control for the contemporaneous government's policy of moving higher education learning online. Finally, we control for the share of the elderly, since age is an important determinant of COVID-19 lethality (SARS-CoV-2 Surveillance Group, 2020[32]), and for mean income because low-income agents tend to have worse health (Case and Deaton, 2017[45]).

with the share of workers employed in non-essential businesses (for instance, because people limited shopping and entertainment activities), our estimates on the effectiveness of business shutdowns in reducing mortality would be biased upwards.

31. In Table 3, we check whether mobility patterns before the government's lockdown differed in local labour markets with low and high shares of workers employed in non-essential sectors. We compare the mobility patterns during the period between the detection of the first community case and the government's lockdown in local labour markets with a low share (below the 25th percentile of the business shutdowns variable distribution) and a high share (above the 75th percentile). Mobility generally decreased relative to the period before the detection of the first community case, but it did to a similar extent across both types of labour markets (non-statistically significant difference).

Table 3. Change in mobility before the lockdown

	Local labour markets with low share of non-essential employment	Local labour markets with high share of non-essential employment	p-value
Workplaces	-9.25	-8.27	0.11
Transit places	-16.36	-14.43	0.19
Retail and recreation	-9.74	-9.15	0.52

Note: The table shows the average daily percent change in mobility during the period between the detection of the first community case (20th February 2020) and the imposition of the government lockdown (11th March 2020) relative to the baseline 3rd January 2020-6th February 2020 period in local labour markets with a low (below the 25th percentile of the business shutdown variable distribution) versus a high share of workers employed in firms affected by the business shutdowns. The column p-value reports the p-value associated with a test for equality in the means.

3.3. An aproximate quantification of the impact of business shutdowns on saved lives

32. How many deaths can be ascribed to COVID-19? And how many deaths have been prevented by shutting businesses down? We answer these questions through some simple calculations. We start by using the coefficients estimated through Equation (3) to calculate the number of excess deaths, in each day of the epidemic and each local labour market, according to the following formula:

$$\hat{Y}_{it} = \left(\hat{\beta}_t + \hat{\lambda} * BS_{it} + \sum_{k=1}^{5} \hat{\pi}_k * X_i^k\right) * pop_i \qquad (4)$$

where $\hat{Y}_{it}$ is the predicted number of deaths due to COVID-19 in local labour market *i* in day *t*; the $\hat{\beta}$s, $\hat{\lambda}$, and $\hat{\eta}$s are the coefficients estimated from Equation (3); BS_{it} is the employment share in shutdown firms; the X^ks are the control variables discussed above; pop_i is population (in 100,000). We calculate $\hat{Y}_{it}$ using the coefficients reported in Column 6 of Table 1 and then sum each $\hat{Y}_{it}$ over the entire period of the first wave of the COVID-19 epidemic in Italy (February/21st to May/15th period), and across all local labour markets. This back-of-the-envelope calculation indicates that COVID-19 resulted in almost 45,000 excess deaths – about 0.13% of the local population – during the first wave of the epidemic in the ten regions of Italy's north.

33. Next, to get a rough sense of the efficacy of the business shutdown policies in reducing mortality, we calculate the number of excess deaths that would have occurred in a hypothetical scenario of no business shutdowns. To do so, we artificially set the variable BS_{it} in Equation (4) equal to 0 and find that deaths would have been more than 87,000 – over 94% more than those that occurred – in absence of business shutdowns.

34. Our estimates thus suggest that business shutdowns almost halved the number of COVID-19 deaths. Two caveats are however in order. First, in Italy business shutdowns coincided with the lockdown

period. Hence, our results are conditional on a lockdown being in place and should not be generalised to cases in which business shutdowns are disjoint from lockdown policies. Moreover, it may be that some non-essential businesses would have closed even in the absence of government-mandated policies. If this were to be the case, we would be overestimating the deaths that were prevented through the government policies. On the other hand, our back-of-the-envelope calculations assume that COVID-19 has linear effects on mortality. However, when infections are left unchecked and the healthcare system is overwhelmed, the fatality rate of COVID-19 increases (Ciminelli and Garcia-Mandicó, 2020[37]; Favero, 2020[38]). In this sense, our calculation of 42,000 prevented deaths may be a lower bound of the real effects of business shutdowns on mortality.

4. Extensions

4.1. The importance of timely interventions

35. Given that infections grow exponentially, the effects of mitigation and suppression policies should be stronger if implemented earlier in the epidemic curve. Dave et al. (2020[19]) and Friedson et al. (2020[39]) show that this is indeed true for the case of lockdowns. In this section, we investigate to what extent this is valid for business shutdowns. We exploit the fact that, while the government applied its policies at the same time throughout the entire country, communities were at different stages in their epidemic curve when they were affected by the shutdowns. Those close to the epidemic epicentre (usually defined as the towns of Codogno and Alzano Lombardo in the Lombardy region) displayed much higher death rates relative to those far from it when the business shutdown policies were implemented (Annex Figure A.3). Hence, the variation across local labour markets in the timing of the policy implementation relative to the stage of the epidemic can be considered as being exogenous to the policy itself.

36. We proceed by constructing a variable measuring the differences across local labour markets in the relative "timing" of the policy implementation. To do so, we calculate the cumulative number of cases reported up to the day in which the government policies were implemented as a share of the local population. On average, detected cases were about 130 per 100,000 people when business shutdowns were adopted. But there was great heterogeneity across local labour markets. Some had recorded as little as 1 case per 100,000 people, while others had almost 1,700. To estimate the importance of timing, we augment Equation (3) by adding an interaction term that is the product of the timing variable, the variable measuring the employment share in shutdown sectors (BS_{it}) and the year 2020 dummy (d^{2020}).[15]

37. Table 4Table 4 below shows the results. All specifications also include our baseline control variables, but for the sake of brevity, their coefficients are not reported. Column (1) reports the results from our baseline specification (Column 6 of Table 1). Column (2) shows estimates from an extended specification accounting for the timing of the business shutdowns relative to the stage of the epidemic. The interaction between the business shutdowns and the timing variables enters with a positive sign and it is statistically significant at the 90% confidence level. This suggests that, on average across the entire period considered, communities in which the policy was implemented at a later stage in the infection curve benefited less from it.

38. The relative timing of business shutdowns should be more important for the short-run effectiveness of the policy; The longer the policy is implemented, the more differences in infection rates at the time of

[15] In practice, the additional regressor that we include in the specification is as follows: $d_j^{2020} \times BS_{it} \times Z_k/pop_k$, where the subscript *k* denotes province *k*; Z_k measures cumulative cases up to the day in which the policy is implemented; pop_k is population size; and the rest is as in Equation (3) above. We use data on cases at the provincial-level (rather than at the local-labour-market-level) since official data on detected cases are only available at this level of disaggregation. Hence, our measure of timeliness is province- rather than local-labour-market-varying.

implementation are washed out. Column (3) shows estimates from an extended specification in which the effectiveness of business shutdowns and the importance of implementation timing are allowed to differ across sub-periods. The new estimates highlight that the timing matters particularly for the short-run effects of the policy. In the first two weeks after implementation, the effectiveness of business shutdowns is more than one third lower in local labour markets with one standard deviation higher cumulative caseload. Instead, in the third and fourth weeks of business shutdowns, their effectiveness is only marginally higher in local labour markets where the policy was implemented relatively earlier. The effects of timing are even somewhat reabsorbed in the fifth and sixth weeks.

Table 4. The effects of business shutdowns accounting for timing

	(1) Baseline	(2) Average	(3) By period
Business shutdowns	-0.52***	-0.54***	
	(0.10)	(0.10)	
Business shutdowns (week 1-2)			-0.96***
			(0.20)
Business shutdowns (week 3-4)			-0.61***
			(0.10)
Business shutdowns (week 5-6)			-0.35***
			(0.10)
Business shutdowns*timing		0.02*	
		(0.01)	
Business shutdowns*timing (week 1-2)			0.32***
			(0.04)
Business shutdowns*timing (week 3-4)			0.03**
			(0.02)
Business shutdowns*timing (week 5-6)			-0.03**
			(0.01)
Observations	80,487	80,487	80,487
R-squared	0.25	0.25	0.26

Note: See notes to Table 1. Column (1) report the preferred baseline specification (Column (6) in Table 1). Column (2) reports estimates of Equation (3), augmented with the interaction $d_j^{2020} * BS_{it} * Z_k/pop_k$. The coefficient of this interaction is reported in the second row, and measures the effectiveness loss of business shutdowns in reducing mortality in local labour markets having a one standard deviation higher cumulative case load at the time of the policy implementation. Column (2) shows the average effect of the $d_j^{2020} * BS_{it} * Z_k/pop_k$ interaction, while Column (3) allows the effect to vary over the different periods of the epidemic.

39. Our results beg the natural question of how many more lives could have been saved had the government intervened earlier in the epidemic curve. To answer this question we use the estimates from Column (3) of Table 4 above to perform some back-of-the-envelope calculations, similarly to what done in Section 3.3. We find that excess deaths during the pandemic period would have been about 35,000 – almost 25% lower – had the business shutdowns been implemented one week earlier, when cumulative cases per 100,000 inhabitants were around 20 on average.[16]

[16] These calculations assume the same number of days of policy implementation (51), but (i) evaluate the coefficients estimated for the interaction between the business shutdowns and timing variables as if the policy was implemented one week earlier, and (ii) give higher (lower) weights to the coefficients estimated for the first (last) two weeks of policy implementation.

4.2. Heterogeneity in the effectiveness of business shutdowns across sectors

40. The analysis carried out so far suggests that business shutdowns are generally effective in reducing COVID-19 mortality. However, there may exist heterogeneities depending on which sectors are affected. Consumer-facing service activities have the potential to amplify contagion due to the high degree of interpersonal contact between workers and customers (Markowitz, Nesson and Robinson, 2019[4]; Lewandowski, 2020[5]). In this section, we extend the analysis to explore such heterogeneities, focusing in particular on four broad sectors: (i) retail trade, (ii) hospitality (food services and accommodation activities), (iii) manufacturing and construction, and (iv) office activities (real estate, professional and administrative and support activities). Together, these account for more than 70% of overall employment (Annex Table A.3) and an even larger share of GDP (Navaretti et al., 2020[40]).[17] Understanding whether there exist heterogeneities in the effectiveness of business shutdowns across these sectors would help policy-makers implement targeted interventions that minimise the trade-off between the number of lives saved and the economic costs.

41. For the estimation, we twist Equation (3) and replace the variable BS_{it} with sector-specific variables measuring, within each sector, the employment share in firms that are closed down. Table 5 below reports the results. In Columns (1)-(4) we show estimates when considering each sector separately one at a time, while Column (5) reports estimates from a comprehensive specification including all the five sectors. The coefficients report the change in daily deaths per 100,000 inhabitants associated with a 10 percentage points increase in the employment share in shutdown firms. All specifications also include our baseline control variables (as in Column (6) of Table 1), but for the sake of brevity, their coefficients are not reported.

Table 5. Sector-specific effects of business shutdowns

	(1)	(2)	(3)	(4)	(5)
Retail trade	-0.36				-0.32
	(0.26)				(0.23)
Hospitality		-0.60***			-0.57***
		(0.20)			(0.20)
Manufacturing & construction			-0.12		-0.11
			(0.09)		(0.08)
Office activities				-0.25***	-0.04
				(0.10)	(0.10)
Observations	80,487	80,487	80,487	80,487	80,487
R-squared	0.25	0.25	0.25	0.25	0.25

Note: See notes to Table 1. This table reports results for the sector-specific effects of business shutdowns in reducing mortality. Columns (1)-(5) report coefficients when each sector is considered one at a time. Column (6) considers all sectors at the same time. The coefficients are estimated using the employment share, within each particular sector, in shutdown firms in place of the variable BS_{it} in Equation (3).

42. The results point to important heterogeneities in the effectiveness of business shutdowns across sectors. Closing down hospitality activities is by far the most effective way to reduce mortality. We estimate a negative and highly statistically significant coefficient in the restricted (Column 2) and extended specifications (Colum 5). Instead, our estimates suggest that closing down manufacturing and construction activities is not effective. The coefficients that we estimate are close to, and not statistically different from, zero (Columns 3 and 5).

[17] Using Italy's data, Navaretti et al. (2020[40]) compute the GDP loss that would occur if each industry were to be closed for one year. Of the 12 industries that would cause the most significant costs, 9 belong to the 5 sectors that were most affected by the shutdowns.

43. The evidence on the effectiveness of shutting down retail trade and office activities is more mixed. The coefficients estimated for retail trade are negative and economically meaningful, but not statistically significant at standard confidence levels (Columns 1 and 5). The coefficients for office activities, instead, are negative (albeit small in absolute value) and statistically significant when the variable enters the regression independently (Columns 4), whereas they lose importance and significance in the extended specification (Column 5).[18]

44. While the evidence on the effectiveness of retail trade and office activities shutdown is mixed, our results on the closure of the hospitality versus the manufacturing and construction sectors are unequivocal. Closing down the former is very effective in reducing mortality while shutting down the latter is not. What could explain this result? One possibility is that even if manufacturing and construction workers affected by shutdowns did stay home, those who kept working because they were employed in essential activities did not contribute to the further spread of COVID-19. Another possibility is that the shutdowns of manufacturing and construction activities did not bind, meaning that workers still went to the workplace notwithstanding the government's order. In this case, our variable measuring the share of workers that stayed at home would be measured with an error. We rule out the latter explanation in the following section.

4.3. Effects of business shutdowns on mobility

45. In section 3.2, we established that there are no differential mobility patterns across local labour markets by share of non-essential businesses. We now move on to investigating how much business shutdowns affected mobility patterns altogether. We estimate four different regressions in which the dependent variables are daily percent changes in mobility in, respectively, workplaces, transit places, retail and recreation venues, and residential places. The explanatory variables are the sector-specific business shutdown variables, interacted with 0/1 policy dummies, as well as our baseline control variables (as in Equation 3) and time fixed effects.[19] Table 6 below reports the results. For each different dependent variable considered, the table also reports the overall effects of business shutdowns on mobility (that is, without distinguishing by sector).

[18] The lack of statistical significance for the retail trade shutdown coefficient might be due to the low variation of shutdown employment in the retail trade sector across local labour markets (see Annex Table A.3). The fact that the office activities shutdown variable lose importance in the extended specification may be because the share of employment in shutdown firms in this sector displays a fairly high correlation with the hospitality shutdown variable across local labour markets (0.46).

[19] Google mobility data are only available for the post-15th February period for the year 2020. Hence, the estimation sample is considerably reduced relative to our other analyses.

Table 6. Effects of business shutdowns on mobility

	(1) Workplace	(2) Workplace	(3) Retail & recreation	(4) Retail & recreation	(5) Transit hubs	(6) Transit hubs	(7) Residential	(8) Residential
Business shutdowns	-1.24***		-1.32**		-1.49**		0.57***	
	(0.19)		(0.53)		(0.64)		(0.09)	
Retail trade		-0.74		1.10		0.18		0.64*
		(0.80)		(0.97)		(1.39)		(0.33)
Hospitality		-0.21		-2.72***		-3.79***		0.12
		(0.33)		(0.99)		(1.16)		(0.18)
Manufact. & construction		-1.27***		-0.41		-0.53		0.59***
		(0.18)		(0.32)		(0.40)		(0.09)
Office activities		-0.72**		-0.17		-0.17		0.22*
		(0.29)		(0.25)		(0.40)		(0.11)
Observations	22,496	22,496	22,496	22,496	22,496	22,496	22,406	22,406
R-squared	0.97	0.98	0.99	0.99	0.98	0.98	0.97	0.98

Note: The table reports the effects of business shutdowns on mobility. Dependent variables measure daily percentage change in mobility relative to the 3rd January to 6th February 2020 period. In Columns (1) and (2), (3) and (4), (5) and (6) and (7) and (8) the dependent variable measures, respectively, workplace mobility, retail and recreational mobility, transit places mobility and residential mobility. The explanatory variables are the overall and sector specific business shutdowns variables, in which the employment share in shutdown sectors is interacted with 0/1 policy dummies taking value 1 during the business shutdown period and 0 otherwise. The estimation sample goes from February 15th to May 15th 2020. The estimating equation includes time and local labour market fixed effects.

46. The new estimates indicate that, overall, business shutdowns reduced visits to the workplaces (Column 1), transit hubs (Column 3) as well as visits to retail and recreational venues (Column 5), while they contributed to increase the time that people spent at home (Column 7). Zooming in on sector-specific effects, the shutdown of manufacturing and construction activities substantially decreased workplace mobility (Column 2) and increased residential mobility (Column 8) as affected workers were forced to stay home. Qualitatively similar, albeit quantitatively smaller, effects are estimated for the shutdown of office activities. As expected, the shutdown of non-essential hospitality activities decreased visits to recreational venues and also trips to transit hubs, while the closure of non-essential retail activities increased the time spent at home.

47. Overall, these results suggest that the shutdown of non-essential services as well as that of non-essential production activities are effective in reducing mobility. Hence, the lower effectiveness of production activities (particularly manufacturing and construction) is not due to low compliance rates. Rather, differential degrees of interpersonal contacts are likely to play an important factor in the spread of COVID-19 at the workplace. While workers in the service sector interact with consumers every day – the opposite of social distancing – for the most part, factory and office workers only interact with other workers in the same unit, and the opportunities to contract or spread the virus appear to be more limited than in the consumer-facing service sector. This can explain why communities with a higher share of employment in shutdown production activities did not experience lower rates of COVID-19 mortality.

48. Our results are in line with the findings on occupational exposure to COVID-19 of Lewandowski (2020[5]) and Aron and Muellbauer (2020[7]). In particular, the latter uses excess mortality data for England to find that most of COVID-19 deaths in the working-age population were concentrated among people employed in the consumer-facing service sector. Our results also have clear policy implications. Governments should not hesitate in closing down services if they want to reduce COVID-19 mortality. On the other hand, they should carefully weight the less clear benefits of closing down factories against the undoubted costs of the halt in production.

5. Conclusions

49. The sudden appearance of COVID-19 in early 2020 has brought about large human losses in most countries around the world, often forcing governments to implement hastily arranged policies to limit the death toll from the virus. The closure of non-essential commercial and production activities (commonly referred to as business shutdowns) has been one such policy. This paper investigated its effectiveness in reducing COVID-19 mortality by using highly granular daily death registry and employment data for thousands of municipalities in Italy's north, for long the world's worst affected area by COVID-19. To carry out the analysis, we exploited a peculiarity in the implementation of the policy in a diff-in-diff approach à la Rajan and Zingales (1998[2]) that allowed us to credibly mitigate endogeneity concerns. Rather than targeting specific firms in specific communities, the government ordered the closure, throughout the country and at the same time, of all firms not operating in essential sectors. By calculating the employment share in shutdown sectors, we were thus able to isolate variation in the degree that communities were affected by the business shutdowns.

50. Our results, which are robust to controlling for a host of co-factors, offer strong evidence that business shutdowns can be very effective in curbing COVID-19 mortality. Using our estimates to perform some back-of-the-envelope calculations, we calculated that business shutdowns might have halved the death toll of COVID-19 during the first wave of the epidemic in Italy. This estimate may even be a lower bound of the lives saved through business shutdowns in Italy's first wave, since the mortality effects of COVID-19 increases when the healthcare system becomes overwhelmed.

51. We also found that implementing business shutdowns early on in the epidemic curve increases their effectiveness. If the policy had been introduced one week earlier the death toll may have been reduced by up to an additional 25%. We also explored heterogeneity in the effectiveness of business shutdowns across sectors. Consistent with the notion that sectors with a higher degree of interpersonal contact can facilitate the spread of infectious diseases, we found that closing down the hospitality sector has the largest effects in reducing mortality. Shutting down the construction and the manufacturing sectors – in which interpersonal contact is limited to workers in the same unit – only has mild effects.

52. Our analysis carries clear policy implications. From a public health perspective, governments should not hesitate to act early on and decide the closure of non-essential businesses in order to save lives when new outbreaks of COVID-19 and other pathogens materialise. However, since business shutdowns carry large economic costs they should be targeted, prioritising the closure of sectors with a high degree of interpersonal contact between workers and customers and a low propensity toward digital labour. Our strong results and related policy implications should be interpreted in the context of the first wave of COVID-19 in Italy, in which strict restrictions on people's movement was in place, but where other protective measures, such as mask-wearing, frequent disinfection, and social distancing measures in public places, were not widespread (Égert et al., 2020[41]). As these measures become the norm, the contribution of business shutdowns to reducing COVID-19 mortality may become smaller.

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Annex A. Additional tables and figures

Table A.1. Data coverage

Region	# municipalities	# local labour markets	Population (in 1,000)
Emilia-Romagna	340	39	4,615.82
Friuli Venezia Giulia	213	11	1,310.69
Liguria	244	14	1,649.38
Lombardy	1,506	51	10,665.40
Marche	229	25	1,611.51
Piedmont	1,180	36	4,715.71
Tuscany	285	26	1,180.36
Trentino-Alto Adige	270	48	3,803.21
Valle d'Aosta	74	5	147.93
Veneto	554	43	5,051.35
Total	4,895	298	34,751.36

Note: the columns “# municipalities” and “# local labour markets" report the number of municipalities and local labour markets covered in the analysis. The columns “population (in 1,000)" report the population covered (in thousands).

Table A.2. Variables sources and descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Period	Source
Mortality rate	3.87	0.86	1.76	7.77	2015-2020	Own calculations from ISTAT, Dataset con i decessi giornalieri
Business shutdowns	50.69	9.00	24.71	78.72	2017	Own calculations from ISTAT, Atlante Statistico dei Comuni
Share working age females	49.70	0.81	46.39	51.48	2015-2019	Own calculations from ISTAT, Indicatori Demografici
Share high school graduates	58.12	5.99	33.34	71.26	2015	Own calculations from ISTAT, Condizioni Socio-Economico
Population density	2323.59	790.26	798.61	5788.94	2017	Own calculations from ISTAT, A Misura di Comune
Days PM10 above limit	37.24	26.81	0.16	90.00	2015-2016	Own calculations from ISTAT, Dati Ambientali nelle Citta
Digital labor in active firms	0.47	0.06	0.24	0.68	2017	Own calculations from ISTAT, Atlante Statistico dei Comuni and own calculations
University closure	27.94	6.83	2.19	51.15	2017	Own calculations from ISTAT, A Misura di Comune and own calculations
Internal commuting index	33.83	13.63	0.24	66.11	2011	ISTAT, Sistemi Locali del Lavoro, 2011
Share of 80+	7.83	1.50	4.57	12.65	2015-2019	Own calculations from ISTAT, Indicatori Demografici
Mean income	14100.95	1612.83	7630.78	18745.39	2015-2017	Own calculations from ISTAT, A Misura di Comune
Transits mobility	-55.72	5.05	-71.63	-43.53	2020	Own calculations from Google Mobility Reports
Retail & recreation mobility	-59.85	2.18	-66.18	-54.70	2020	Own calculations from Google Mobility Reports
Workplace mobility	-43.38	2.51	-52.57	-38.86	2020	Own calculations from Google Mobility Reports
Residential mobility	20.77	1.24	18.21	24.57	2020	Own calculations from Google Mobility Reports

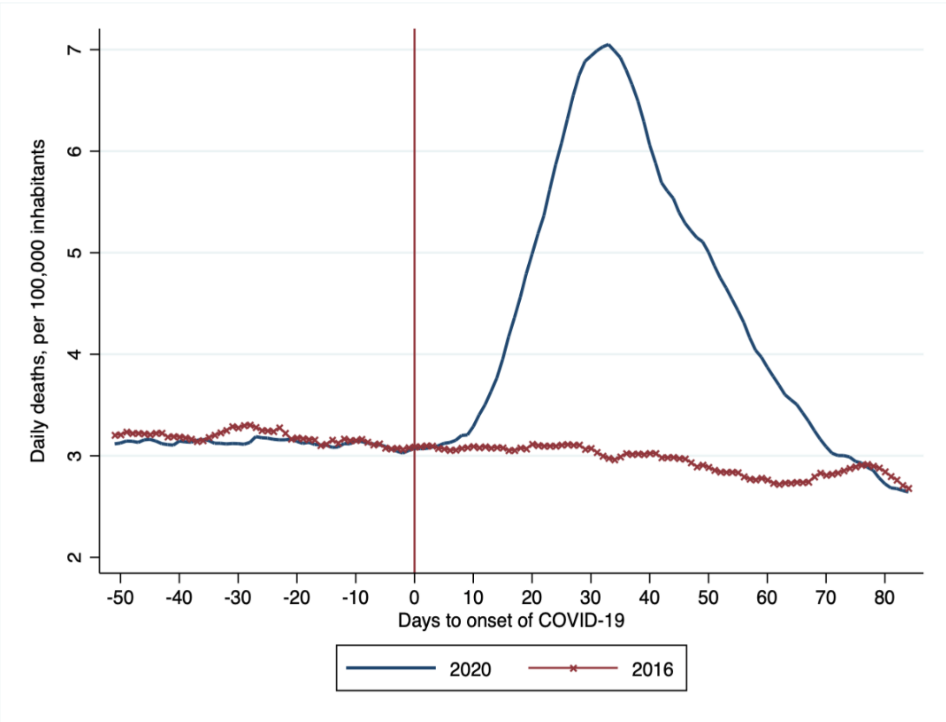
Note: Mortality rate measures daily deaths per 100,000 inhabitants. Business shutdowns measure the employment share in shutdown firms (in %), population density measures population over inhabited land. Days PM10 above limit measures the number of days in a year in which PM10 averages above 50 mg/mq3. Digital labour in active firms measure the weighted sum of employment across industries using digital labour scores as a share of total employment. University closures measures the share of people enrolled at university over the 18-25 population. Internal commuting index measures the flows across different municipalities in the same local labour market over total flows. Share 80+ measures the share of people aged 80 and above over the total population (in %). Transits, retail & recreation, workplace and residential mobility measure the percent change in visits to each of these locations relative to the baseline January 3 to February 6 2020 period.

Table A.3. Descriptive statistics on business shutdowns by sector

	NACE Rev 2 code	employment Share	affected by shutdown	share affected mean	share affected s.d.	digital labour
Mining and Quarrying	B	0.13	YES	99.87	0.89	1
Manufacturing	C	27.88	YES	59.51	17.33	3,5
Electricity and Gas	D	0.53	NO	/	/	4
Water supply and waste management	E	0.91	NO	/	/	/
Construction	F	9.36	YES	64.18	7.85	2
Sales of motorveichles	45	2.13	YES	19.41	10.47	/
Wholesale trade	46	5.48	YES	64.98	10.20	4
Retail trade	47	11.00	YES	40.82	3.92	1
Transportation and storage	H	4.69	NO	/	/	2
Hospitality	I	11.68	YES	94.70	4.25	1
Information and communication	J	1.48	NO	/	/	6
Financial and insurance activities	K	0.84	NO	/	/	5
Real estate activities	L	2.12	YES	100.00	0.00	2
Professional activities	M	5.62	YES	2.57	1.69	5
Administrative and support activities	N	4.56	YES	19.78	13.14	5
Education	P	0.51	NO	/	/	3
Health	Q	4.15	NO	/	/	2
Entertainment and recreation	R	0.95	YES	100.00	0.00	1
Other service activities	S	2.68	YES	81.85	1.02	3

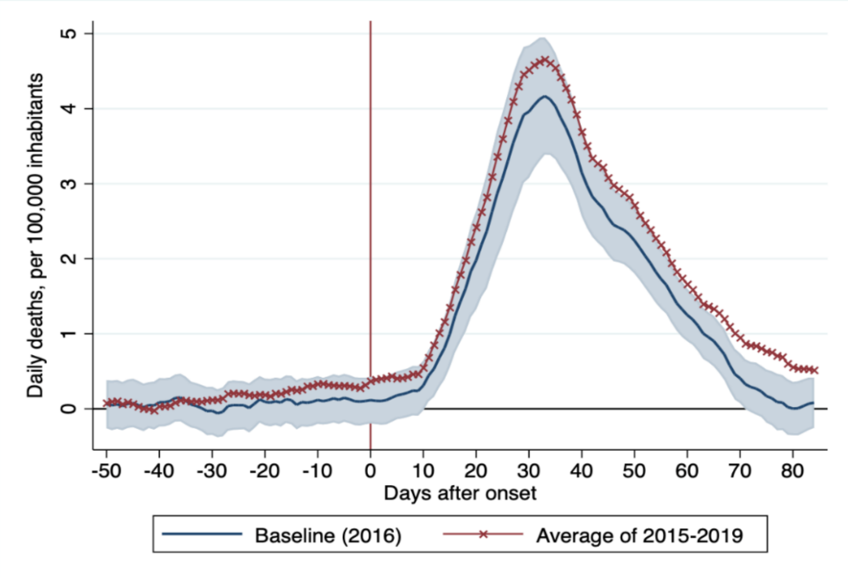
Note: This table divides non-farm private employment in twenty broad sectors. The first and second columns report the name and code, according to the NACE Rev 2 classification, of each sector. The third column states whether a sector is affected by the shutdowns or not. The fourth and fifth columns report the mean and standard deviation of the employment share in shutdown firms. The sixth column reports the score from the digital labour index of Manyika et al. (2015[33]). Among the manufacturing sector, 20, 21, 254, 26, 27, 28, 29, 30 and 325 industries (high-tech manufacturing) receive a score of 5, while all others (low-tech) receive a score of 3.

Figure A.1. Daily mortality trends



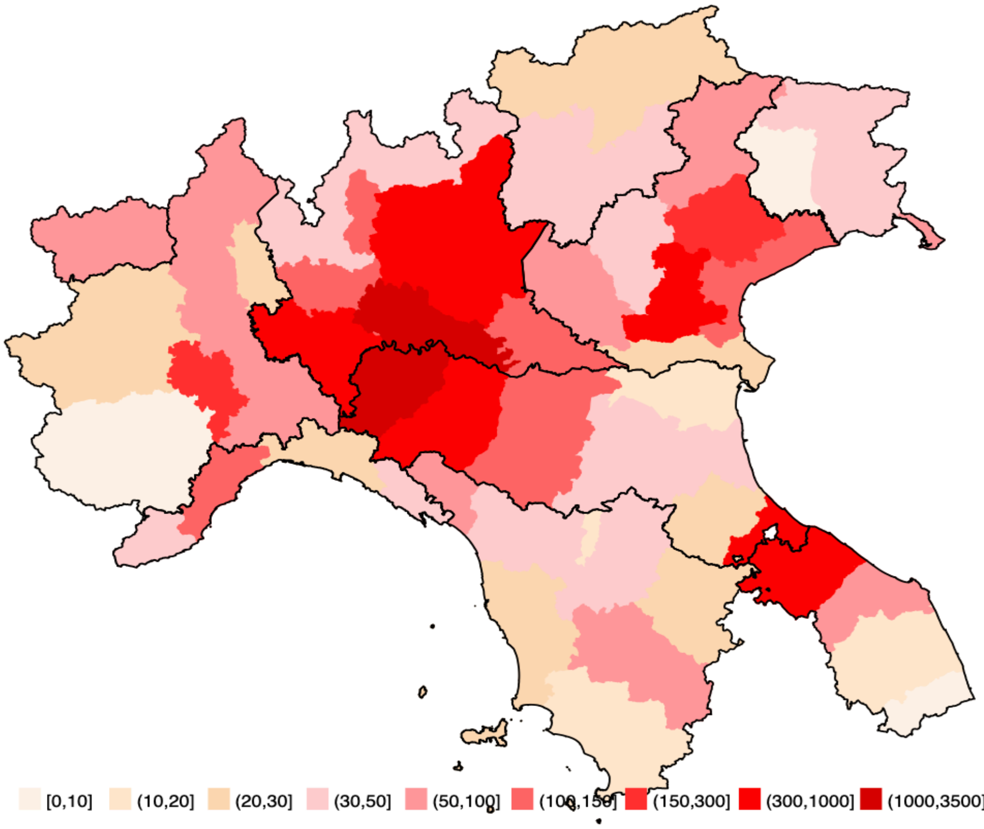
Note: This figure plots mortality trends in 2020 and for the synthetic control group, constructed following Abadie et al. (2020[34]).

Figure A.2. Robustness of the estimates to the control group



Note: The figure shows the estimated effects of COVID-19 on mortality using 2016 as control group (in blue) and its 95% confidence bands. In red, it shows the estimated effects using the average mortality of years 2015-2019 as control group.

Figure A.3. Number of cases at the time of business shutdowns



Note: The figure shows the number of confirmed COVID-19 cases at the provincial level at the time in which the business shutdowns were implemented by the government.