



From the lockdown to the new normal: individual mobility and local labor market characteristics following the COVID-19 pandemic in Italy

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Abstract

Italy was among the first countries to introduce drastic measures to reduce individual mobility in order to slow the diffusion of COVID-19. The first measures imposed by the central authorities on March 8, 2020, were unanticipated and highly localized, focusing on 26 provinces. Additional nationwide measures were imposed after one day, and were removed only after June 3. Looking at these watershed moments of the pandemic, this paper explores the impact of the adoption of localized restrictions on changes in individual mobility in Italy using a spatial discontinuity approach. Results show that these measures lowered individual mobility by 7 percentage points on top of the reduction in mobility recorded in the adjacent untreated areas. The study also fills a gap in the literature in that it looks at the changes in mobility after the nationwide restrictions were lifted and shows how the recovery in mobility patterns is related to various characteristics of local labour markets. Areas with a higher proportion of professions exposed to diseases, more suitable for flexible work arrangements, and with a higher share of fixed-term contracts before the pandemic are characterised by a smaller increase in mobility after re-opening.

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1 Introduction

Facing the outbreak and diffusion of COVID-19, Italy was the first European country to announce and implement in early March 2020 severe limits on travelling and individual mobility with the aim of slowing down the contagion. Soft recommendations to ‘stay-at-home’ were transformed into legally binding orders and lockdown restrictions enforced via civil and criminal law measures. On March 8, severe mobility restrictions were imposed on 14 provinces and one region in the Centre-North; two days later, these measures were extended to the entire country and were progressively strengthened through the suspension of most economic activities, but for the so-called essential sectors exempted from the ban. In parallel, the authorities started facilitating work-from-home (WFH) practices by waiving existing laws and collective agreements that limited WFH. Nationwide restrictive measures remained in force until May 4, when they started being progressively removed. Individual mobility across regions was permitted again on June 3, when the nationwide restrictions were removed. Individual mobility increased on average to the pre-lockdown levels but followed differentiated patterns that characterize a ‘new normal’.

This brief account of the events allows us to spot two relevant dates: on March 8, the national authorities unexpectedly decided to impose highly localized restrictions on individual movements that started the following day, thereby affecting local mobility patterns on top and above what was happening in the rest of the country; on June 3, nationwide mobility restrictions were lifted, creating the opportunity for people to move freely. In this study, we focus on these two dates and events to analyze how the restrictions affected individual mobility in the context of the COVID-19 pandemic and how the characteristics of local labour markets, e.g., ability to WFH, are related to the evolution of local mobility patterns after the restrictions were lifted.

More specifically, we empirically explore what happened to individual mobility in these peculiar circumstances so as to address two separate, but connected, issues. First, we investigate how the abrupt imposition of the targeted travelling bans on 26 provinces on March 9 affected local mobility patterns. Thanks to the intrinsic characteristics of the policy decisions, we are able to causally identify the effects of the restrictions. We find robust evidence that localized lockdowns were immediately effective in Italy as within just a few hours they reduced individual mobility by an additional 50% with respect to the decrease in the control municipalities (i.e., about 7 percentage points on top of the 13% reduction in mobility recorded on average on that day).

Second, we explore what happened to mobility when the measures were removed on June 3. In particular, we study how the characteristics of local labor market areas (LLMAs) are related to the observed changes in mobility patterns, thereby filling a gap in the literature on the determinants of mobility in the COVID-19 period. We find

that the recovery of mobility was highly differentiated across LLMAs; for instance, where the ability to WFH and the share of expired fixed-term contracts (not covered by the furlough scheme adopted by the Italian government) were higher, the observed increase in mobility once the lockdown was lifted was smaller. Changes in mobility after the lifting of restrictions were also negatively associated with the local share of professions exposed to the risk of contagion (as they were probably the last occupations to be actually re-activated, even when legally possible) and with the local activity rate because most economic activities remained subject to various restrictions. All of these results hold when controlling for other relevant local features, such as the composition by age of the population, the size of the LLMA, topographic characteristics of the areas and the importance of tourism in the local economy. Although in this second part we refrain from claiming to have found any causal effects, due to the lack of a proper control group (as the restrictions were lifted on the entire country), our analysis provides the first evidence of a relationship between the pace of local mobility resumption and the characteristics of local labour market areas.¹

From a methodological viewpoint, in this study we adopt two distinct and complementary approaches to assess empirically both the impact of the restrictions and the implications of their lifting on local mobility. First, as to the localized lockdown measures, the identification strategy exploits the peculiar circumstances making the event a quasi-natural experiment and can be treated as unanticipated by the affected population: the restrictions were localized but decided abruptly and unexpectedly by the national authorities during an extraordinary late-night meeting of the Council of the Ministers (Bonacini et al. 2021a). The authorities, lacking disaggregated and real-time data on the diffusion of the contagion and the actual death toll (Cerqua et al. 2021; Depalo 2021; Manski and Molinari 2021), had to apply the restrictions at the broad provincial level rather than on the municipalities most heavily plagued by the virus. The measures were in place for only a few hours before being extended to the rest of the country as the situation quickly escalated and to avoid spatial arbitrage. Moreover, as done by Goolsbee and Syverson (2021) in their study on local lockdowns and US consumers' mobility, we can leverage the policy discontinuity across neighboring (and otherwise similar) municipalities within the same local labour market areas spanning across provinces that faced different restrictive measures.

Second, as the removal of the nationwide restrictions on June 3 was neither abrupt nor geographically differentiated, we adopt a different strategy to analyze how the recovery in mobility is related to the characteristics of the local labour markets. We exploit the geographical unevenness of COVID-19 diffusion, the heterogeneity of

¹Because the removal of travelling bans on June 3 was applied simultaneously to the entire country, a difference-in-differences approach cannot be used to assess the causal impact of the lift. As acutely pointed out by Dave et al. (2020b), however, even a locally differentiated lifting of the restrictions could not have been exploited to identify causal relationships for two reasons: first, the lifting of mobility restrictions tends to follow observed improvements in infections and hospitalizations, and these latter exert an important confounding effect on individual mobility; second, the assumption of parallel trends between treated and non-treated areas before the removal of the restrictions would be invalid when these measures affect (i.e., reduce) the local diffusion of the virus.

local labour markets, and the spatial differences of individual mobility patterns in Italy.²

This work relates to a lively strand of recent literature focusing on the relationship between mobility and COVID-19, which has not reached yet a consensus on the implications of applying restrictive measures on individual movements. Barnes et al. (2020), Brodeur et al. (2021b), Brzezinski et al. (2020), Couture et al. (2021), Dave et al. (2020a), and Engle et al. (2020) and Goolsbee and Syverson (2021), among others, investigate the implications of stay-at-home orders in the US by focusing either on state-level or county-level restrictions, whereas Barrios et al. (2021) address similar issues for European countries, and Pullano et al. (2020) focuses on internal mobility in France. In contrast to the Italian case, these studies suggest that mobility in the US began to drop well before the imposition of legal orders, as they were adopted rather late and people already started self-restraining influenced by the number of COVID-19 deaths reported (Goolsbee and Syverson 2021; Farboodi et al. 2021; Maloney and Taskin 2020).³ As documented by Milani (2021), almost everywhere in the world the authorities reacted more slowly than those in Italy to the COVID-19 shock.

How mobility recovered after restrictions were removed is the subject of just a few works that explore the mediating role of local temperature and precipitation (Nguyen et al. 2020) and civic capital (Barrios et al. 2021). Goolsbee and Syverson (2021) explore how consumers' visits to shops changed after the shelter-in-place orders were progressively lifted in US counties. With regards to Italy, very limited evidence is available on the opening-up phase, with the exception of Gauvin et al. (2020). They investigate the evolution of mobility before and after the nationwide lockdown measures adopted in mid-March, as well as during the so-called Phase 2 starting on May 4, but use more aggregate data (both in terms of geographic units and periods of time) and do not look at the characteristics of local labour markets.⁴

²Previous studies investigating the regional evolution of individual mobility and social distancing focused on other socioeconomic dimensions, such as ethnic fractionalization and xenophobia (Egorov et al. 2021), political ideology (Barbieri and Bonini 2021), access to high-speed Internet in homes (Chiou and Tucker 2020), income and ability to WFH (Bonacini et al. (2021b) and Papageorge et al. (2021), social capital and trust (Barrios et al. 2021; Borgonovi and Andrieu 2020; Brodeur et al. 2021b; Deopa and Fortunato 2021; Durante et al. 2021), economic dislocation (Wright et al. 2020) and the like. Caselli and Fracasso (2022) provide a discussion of the role of technology in the spread of the virus. Ascani et al. (2021a) and Bloise and Tancioni (2021) discuss the spatial unevenness of COVID-19 diffusion in Italy and the contribution of the characteristics of the local economy at the provincial (NUTS3) level. Ascani et al. (2021a) show that the local specialization did influence the transmission of the virus and, in particular, that the strength of the relationship between the spread of the disease and the local economic structure was due to the specialization in geographically concentrated manufacturing activities, rather than services. Bloise and Tancioni (2021) provide evidence that economic factors (such as the intensity of local economic activities) played a more relevant role than non-economic determinants in the transmission of the virus.

³This is not to say that policy restrictions were unimportant factors in the containment of the virus in the US. For instance, as shown by Amuedo-Dorantes et al. (2021), Chernozhukov et al. (2021) and Fowler et al. (2021), the contribution of legal restrictions cannot be underestimated.

⁴Among the other studies on the impact of the mobility restrictions in Italy, we recall Barbieri and Bonini (2021), who focus on the role played by the political orientation of Italians on individual compliance with the rules, and Pepe et al. (2020), who delve into the reduction of traffic across Italian provinces in early and late March 2020.

Our analysis contributes to the above literature in four directions. First, we empirically assess the relationship between the legal restrictions and the mobility rates at a very granular geographical level, controlling for a number of potentially socio-economic confounding factors. Notably, we rely on mobility restrictions that were imposed by the national government without an anticipation effect and on the basis of large territorial units (i.e., provinces) that include heterogeneous municipalities differing in terms of the diffusion of the virus and other characteristics. Accordingly, unlike previous works, the policy treatment we investigate can be considered as exogenous and be treated accordingly from an econometric viewpoint. Second, our analysis covers the removal of nationwide mobility restrictions in early June, thereby embracing the entire evolution of policy measures, from the early targeted restrictions to the normalization of policy. Third, as mentioned before, we explore for the first time how non-trivial characteristics of the local labour markets are related to the observed changes in mobility patterns. As both the impact of the mobility restrictions and the patterns of COVID-19 diffusion have an intrinsically spatial and regional nature, our attention to the actual impact of the imposition and removal of restrictions on actual mobility patterns contributes to the understanding of the relationship between mobility and public choice.⁵ Lastly, our empirical analysis innovates on the existing works on individual mobility in Italy in that it exploits a unique and innovative dataset merging information from several Italian data sources (more on this in Section 3) with a view to accounting for several relevant characteristics of LLMA.

In addition, this work refers to the literature engaged with modelling the diffusion of the pandemic, such as the SIR modelling (Acemoglu et al. 2020), and in particular the impact of travel bans on the diffusion of the virus (see Ascani et al. (2021b), Bloise and Tancioni (2021), Bourdin et al. (2021), and Favero et al. (2020), and Bilgin (2020), for Italy; Lyu and Wehby (2020), Alfaro et al. (2020), Amuedo-Dorantes et al. (2021), and Glaeser et al. (2020), and Chernozhukov et al. (2021) for the US; Fang et al. (2020) and Kraemer et al. (2020), and Qiu et al. (2020), for China; Coelho et al. (2020), for Brazil; and Amdaoud et al. (2021), Hsiang et al. (2020), Jinjark et al. (2020), Ozkan et al. (2021), and Zimmermann et al. (2020), and Yilmazkuday (2020), for cross-country analyses). Although our study does not address the diffusion of the pandemic, our findings can inform researchers and policymakers interested in modelling the regional evolution of the contagion and the effects of alternative policy measures. As to what concerns the removal of the restrictions, we provide evidence that policymakers may want to take into account the specific features of local labour markets if interested in promoting a fast recovery in mobility to levels close to the pre-pandemic condition.

Our work also refers to the literature exploring what local factors (such as the perception of risk, the trust in the authorities, and the threat posed by the local diffusion of the virus) affect compliance with mobility restrictions and social distancing orders (Durante et al. 2021; Borgonovi and Andrieu 2020; Bargain and Aminjonov 2020;

⁵As discussed by Bailey et al. (2020), the virus and the policy measures contribute to produce spatially heterogeneous consequences in terms of health (Ascani et al. 2021a; Brodeur et al. 2021a; Burlina and Rodriguez-Pose 2020) and economic outcomes (Beland et al. 2020; Gupta et al. 2020; Meinen et al. 2021; Montenovio et al. 2020), among others.

Katafuchi et al. 2021; Karabulut et al. 2021; Deiana et al. 2021). Although conceptually related to these works, our study differs in that it focuses on how socioeconomic and labour market-related factors correlate with the recovery of individual mobility, and not with compliance.

Finally, the focus on the features of the local labour markets makes this work relate to a strand of the literature focusing on the task content of occupations and, in particular, on workers' implied exposure to infections and their personal distancing in the workplace.⁶ Although we cannot detect distinct causal effects linking jobs' and workers' characteristics to individual mobility, our results provide *prima facie* evidence that the diversified composition of LLMA along various dimensions is meaningfully related to the heterogeneous pace in the recovery of mobility towards a 'new normal'. Thus, our findings are in accordance with Cerqua and Letta (2022), who show that, during the first wave of COVID-19 in Italy, the largest employment losses were observed in those labour markets that were characterized by a combination of LLMA-specific features, such as industrial specialization, exposure of economic activities to high social aggregation risks, and pre-existing labour market weaknesses.

The remaining of the paper proceeds as follows. Section 2 illustrates the timeline of the policy measures and mobility restrictions, thereby providing the background to understand the empirical strategies adopted in the analysis. Section 3 describes the data and their sources. Section 4 examines the impact on individual mobility of the restrictions imposed by the Italian government on 26 provinces in the Centre-North of Italy on March 9. Section 5, instead, addresses the gradual opening up process and, specifically, how the removal of the nationwide restrictions imposed by the government at the height of the crisis in late March relate to the characteristics of local labour market areas. Section 6 offers some closing remarks.

2 The timeline of policy measures and mobility restrictions

Facing the outbreak and diffusion of COVID-19, Italy was the first European country to announce severe limits on travelling and individual mobility with the aim of slowing down the contagion. In a few days, the simple recommendations to "stay at home" were transformed into localized restrictive measures whose transgression was punished with civil and criminal sanctions. It is important to notice that these measures came in at a time when poor and often contrasting information about the transmission of COVID-19 was available both to government officials and to the public. In addition, the restrictive measures could not be foreseen and indeed there is evidence of a relevant announcement effect and no anticipation effect (Bonacini et al. 2021a).

⁶Intuitively, these features of occupations are potentially correlated with the impact of social distancing measures and mobility restrictions, in line with the studies showing that the diffusion of the virus and individual mobility have been affected by the composition of the local workforce in terms of occupations and workers' characteristics (Almagro and Orane-Hutchinson 2020; Ascani et al. 2021a; Beland et al. 2020; Crowley and Doran 2020; Leibovici et al. 2020; Koren and Peto 2020; Mongey et al. 2020), in particular their ability of WFH (Barbieri et al. 2022; Basso et al. 2020; Baker 2020; Boeri et al. 2020; Dingel and Neiman 2020; Gottlieb et al. 2020; Hensvik et al. 2020; Holgersen et al. 2021; Mongey et al. 2020; Yassenov 2020).

The first two cases of coronavirus in Italy were detected on January 30, 2020, while the first official cases of secondary transmission were discovered on February 21 in the municipalities of Codogno and Vo' Euganeo. Following these cases, the authorities imposed extreme lockdowns in eleven small municipalities, that were quarantined on March 1. After a few days, on March 8 the Italian Prime Minister Giuseppe Conte announced that, starting the following day, all 12 provinces in Lombardy and 14 provinces in Piedmont, Veneto, Emilia-Romagna, and Marche would be subject to a ban on various economic and social activities, and to severe limitations on individual mobility.⁷ In these so-called “protected areas”, which account for 16 million people in the Center-North of Italy, individuals were not allowed to move between municipalities, but for motivated reasons related to work, health and extraordinary circumstances (subject to authorisation and control). The residents in the rest of the country, instead, were left free to move both within and between municipalities. Such differentiated measures across administrative units did not last long. The following evening, the Italian Prime Minister announced that, starting on March 10, new measures restricting individual mobility would be imposed homogeneously on the entire national territory.

Subsequently, on March 25, the government implemented the temporary suspension of all the economic sectors, with the exception of those considered as “essential activities” (namely, necessary to either the survival of the population or to the full operation of the healthcare sector). After these decrees, around 8 million workers (34% of the total) were forced to stay at home (Barbieri et al. 2022), either working from remote or not. Indeed, institutions and companies were explicitly invited to develop new strategies to facilitate remote work, even derogating to existing laws and collective agreements with the trade unions. As a consequence, WFH was transformed from an extra-ordinary to an ordinary way of working, even for the public administration in which at least 50% of the workforce started working remotely (Bonacini et al. 2021b). Following this latest measure, March 30 represented the first working day of the week when both the restrictions on individual movements and the sectoral lockdown were concurrently implemented nationwide and when individual mobility saw its largest decrease on average.

These measures remained in force until May 4, when the so-called Phase 2 started. In sum, a number of economic activities (for instance, restaurants and cafes) were permitted again, and travelling between municipalities within the same region was allowed if due to work or health reasons as well as for small gatherings with close relatives. On May 18, restrictions on mobility between municipalities of the same region were removed, and people did not need to carry with them an affidavit (*autodichiarazione*) justifying the reason for being outside. Notably, movements across regions (except in cases of absolute necessity, or for urgent work or health reasons) remained forbidden until June 3, when such nationwide restrictions were

⁷Provinces in Italy are NUTS3 areas, in EU jargon. The 12 provinces in Lombardy are: Bergamo, Brescia, Como, Cremona, Lecco, Lodi, Mantova, Milano, Monza e Brianza, Pavia, Sondrio, Varese. The other 14 provinces are: Modena, Parma, Piacenza, Reggio nell'Emilia, Rimini (Emilia-Romagna), Pesaro e Urbino (Marche), Alessandria, Asti, Novara, Verbano-Cusio-Ossola, Vercelli (Piedmont), Padova, Treviso, Venezia (Veneto).

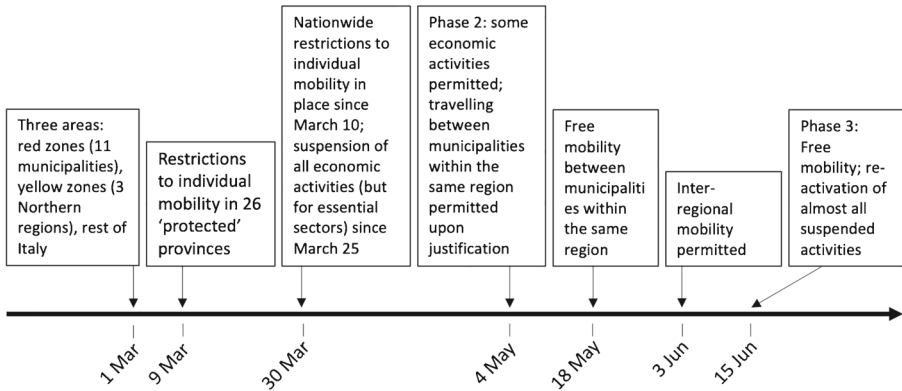


Fig. 1 Timeline of policy measures and mobility restrictions, 2020

removed and the ongoing normalisation process made an important step further. The so-called Phase 3 started right after that, and precisely on June 15, when the ban on most economic activities and on social gatherings was lifted, with face masks and social distancing still mandatory in enclosed public spaces. Figure 1 shows a timeline depicting the main dates and policy measures taken during this period.

The impact of the imposition and of the lifting of restrictions on individual mobility has been, indisputably, huge. Figure 2 shows that, on average, the mobility in Italy collapsed after the measures introduced in March and restarted with their gradual removal in May and June. Although the nationwide mobility patterns accord intuitively well with the implementation of the restrictions, aggregate representations hide a remarkably high regional heterogeneity and do not make it possible to gauge to what extent individual mobility changed because of the policy interventions or rather due to other concurrent factors. Indeed, Fig. 3 shows that while the fall in mobility by March 30 was rather homogeneous (as all areas were subject to the same strict

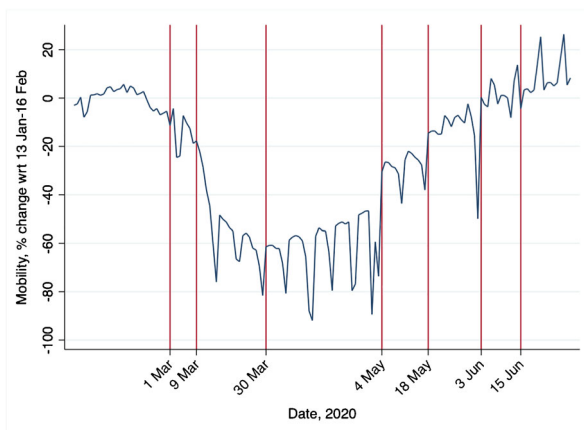


Fig. 2 Variations in mobility relative to January 13-February 16. Source: Authors' calculations based on data from City Analytics - Mobility Map, Enel X s.r.l. and Here Technologies

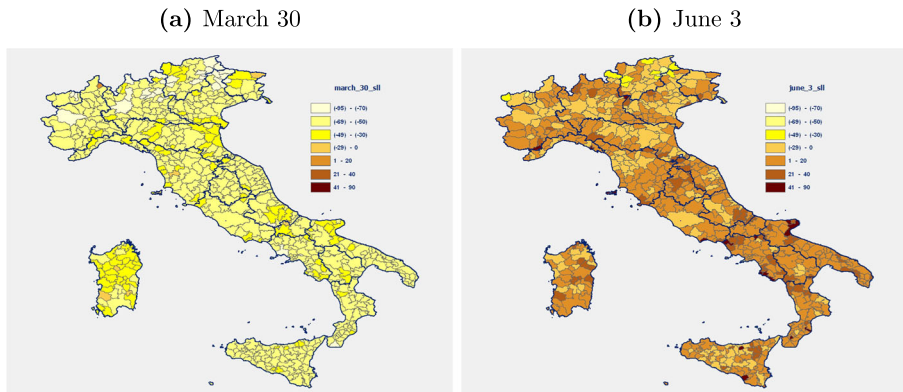


Fig. 3 Variations in mobility on March 30 and June 3 relative to Jan 13-Feb 16. Source: Authors' calculations based on data from City Analytics - Mobility Map, Enel X s.r.l. and Here Technologies

measures), the subsequent increase in mobility after the lifting of the restrictions was heterogeneous across local labour market areas.

Addressing these issues empirically is what this work aims to do in the following sections. In particular, as anticipated in the Introduction, we focus on two events: first, the unanticipated imposition of localized restrictions on 26 provinces in the Centre-North on March 9; second, the removal of nationwide restrictions on cross-regional movements starting on June 3.

3 Data

Analysing the impact of imposing and lifting drastic restrictive measures on individuals' mobility requires, first of all, to look at granular data on the movements of individuals. Moreover, assessing the relationship between the removal of the restrictions and the features of local labour markets requires to build a composite dataset spanning a number of characteristics of the local workforce. Thus, we build a unique and innovative dataset borrowing information from various sources covering the following five aspects: individual mobility; epidemic-related characteristics of occupations and their composition at the local level; composition of the labour force in terms of short-term contracts; other features of local labour markets; various municipal-level controls affecting local mobility patterns, including demographic and geographic characteristics.

As to the individual mobility, one possible approach to build such measure, adopted for instance by Pepe et al. (2020), is to process a large-scale dataset of anonymously shared positions of smartphone users. While this method would in principle make it possible to track the exact movements of each person, the anonymity of data prevents from relating these latter to the characteristics and features of the individuals under scrutiny. Still, it provides useful information to study issues related to social distancing and its determinants.

An alternative approach, suitable to connect mobility patterns with relevant local factors (though at the price of losing track of specific individuals), is to focus on the overall movements occurring within geographical units, for instance by looking at the data collected by Google in its Community Mobility Reports or by Apple in its Mobility Trends Reports, as done for instance by Barnes et al. (2020). This latter approach is the one we adopt in this work. However, given our interest in local mobility patterns and the fact that Google and Apple only provide data aggregated down to the regional level, we have to rely on a novel dataset that provides data aggregated down to the level of municipalities. Thus, we use for the first time the data provided by Enel X s.r.l. in partnership with Here Technologies and developed as part of the project “City Analytics - Mobility Map” launched in Spring 2020 to support government agencies and the Civil Protection department in response to COVID-19.⁸ The companies estimate the percentage change in the public’s daily movements (number of trips) and kilometres travelled throughout national, regional and municipal areas in Italy using anonymized and aggregated data from connected vehicles, maps, navigation systems and mobile apps. Although produced to help government institutions to tackle the emergency, the aggregated data on daily mobility flows have been made freely available to the public, while no information on the actual levels of mobility flows is provided publicly.⁹

In our analysis, we use the percentage change in the daily number of trips at the municipality level compared to the daily average from 13 January 2020 to 16 February 2020, the period that is used as a baseline for each municipality. Although we use data on individuals’ mobility at the municipality level, for the analysis in Section 4 we consider only municipalities belonging to the same local labour market areas, which are sub-regional geographical areas identified on the basis of daily commuting patterns. By doing so, we manage to compare the municipalities affected by the targeted restrictions with the most proximate (and similar) municipalities among the unaffected ones. In Section 5, we aggregate the mobility data at the level of LLMA. As anticipated, LLMA are functional geographic areas that go beyond administrative boundaries and represent economically integrated spatial units where residents can easily commute to work without changing place of residence. This makes LLMA suitable analytical units to study how the removal of restrictive measures on mobility plays out across different labour markets: most of the residents who live in the municipalities included in a LLMA also work in the same LLMA and, thus, mainly move within them. Moreover, previous studies on workers’ mobility, such as Ciani et al. (2017), have shown that changes in local population at the LLMA level are very gradual

⁸Enel X is fully owned by Enel, whose main shareholder is the Italian state through the Ministry of Economy and Finance.

⁹The data collected are statistically representative for each day and each municipality in Italy. In case only few movements within a municipality are recorded, thus making the data potentially not representative, the data for that municipality are discarded (this occurs in less than 1% of municipalities on any single day). Indeed, the overall mobility patterns taken from this dataset are in line with those of Google and Apple, with a raw correlation above 0.8. More information on the dataset (in Italian) and access to the dashboard are available at the following url: <https://www.enelx.com/it/it/smart-city/soluzioni/soluzioni-smart/dashboard-COVID-19>.

and this makes this geographical unit the most suitable to discuss geographical heterogeneity across labour markets (de Blasio and Poy 2017; Caselli et al. 2020).

As to the job characteristics, we consider three indicators accounting for workers' characteristics during the COVID-19 pandemic. These three indicators measure, respectively, the exposure to diseases and infections, the suitability of occupations to be performed remotely, and the relative importance of tasks requiring physical proximity. These features can be used to study mobility patterns as they influence individuals' ability to travel to work during the pandemic, given the imposition and the removal of specific restrictive measures by the authorities. In particular, we hypothesise that a greater share of professions with a high risk of diseases and infections in LLMA significantly reduces the resumption of mobility. Indeed, it has been shown that the risk of disease is higher among professions (typically those in the health sector) that did not stop during the lockdown (Barbieri et al. 2022). Similarly, we expect that a greater ability to WFH may reduce the resumption of mobility because a greater share of workers stay at home to work out of fear or as a result of restrictive measures. We also test the relationship between the degree of physical proximity at work and the recovery of mobility: since the removal of the measures implemented to reduce mobility and social contact in Italy did not explicitly take into consideration the degree of proximity of professions, we do not expect them to have a significant impact on mobility.

To build these three indicators, we exploit detailed information on the task content of jobs at the 5-digit occupation-level, using data drawn from the Survey of Professions (ICP), a survey last released in 2013 by the Italian National Institute for Public Policies Analysis (INAPP). The ICP surveys about 16,000 workers covering the whole spectrum of the Italian classification of occupations (i.e. 811 occupational codes according to the 5-digit CP2011 classification, the Italian equivalent of ILO's ISCO-08 classification). The ICP is a unique source of information on skill, task and work contents, since it evaluates the characteristics of the occupations through a particularly rich questionnaire articulated in seven sections (knowledge, skills, attitudes, generalised work activities, values, work styles and working conditions). In fact, the ICP is the Italian equivalent of the American O*Net and is the only survey replicating the O*NET structure outside the US. Both the American O*Net and the Italian ICP allow to produce occupation-level variables by relying on both survey-based worker-level information as well as on post-survey validation by experts' focus groups. The ICP sample survey ensures representativeness with respect to sector, occupation, firm size and geographical domain (macro-regions). The survey includes more than 400 variables on skill, work contents, attitudes and tasks and, on average, 20 workers for each Italian occupation are included providing representative information at the 5th digit.

These three innovative measures are borrowed from the recent contribution by Barbieri et al. (2022), who evaluate the correlation between the lockdown measures in Italy and workers' risk of contagion. For each measure, they assign an ordinal score on a scale from 0 to 100 (from less to more intense) for each 5-digit occupation. We refer to Barbieri et al. (2022) for more details on the construction of each measure. We take these values by occupation to the level of LLMA by using weighted

averages based on the sample weight of each 5-digit occupation within total LLMA employment taken from the 2019 Labour Force Survey (LFS).¹⁰ Given that the LFS covers only 465 out of 611 LLMA, this creates some missing observations for these three variables and restricts the sample.

It is worth noticing that the use of ICP in this work is an important methodological aspect as it differentiates it from those studies adapting the O*Net classification to categorise Italian or European occupations. The task and skill variables that ICP produces and that we use are specifically related to the Italian economy and capture the exact structure of the Italian labour markets, the level of technology and the system of industrial relations that characterise the Italian economy.¹¹

Local mobility for work-related reasons may reflect also the structure of employment in terms of fixed-term and open-ended contracts. As the Italian furlough scheme adopted to address the impact of the pandemic and of the lockdown was meant to preserve permanent jobs and their reactivation once the restrictive measures were gradually lifted, most of the workers with fixed-term contracts that expired during the Spring 2020 lost their jobs (Banca d'Italia 2020). Hence, we build a variable to control for the local relative importance of short-term contracts. Since in Italy there is an intense use of fixed-term contracts but with great variation across LLMA, this variable may capture the substantial degree of heterogeneity in labour markets across different Italian areas (Garibaldi and Taddei 2013), which in turn helps to explain the different changes in individual mobility across LLMA after the removal of the restrictions.

The best way to account for the local characteristics of job contracts is to use the Integrated Sample of Mandatory Communications (*Campione Integrato delle Comunicazioni Obbligatorie*, CICO), a very large dataset based on a random sample of employees and quasi-employees from administrative-level data (*Sistema delle Comunicazioni Obbligatorie*, COB) provided by the Italian Ministry of Labour and Social Policies. In any given year and for each cohort of birth, the dataset gathers all individuals who are born on the 1st, the 9th, the 10th and the 11th of each month. It includes detailed information on the flow of all job contracts activated, transformed and dismissed for dependent and independent workers in all economic sectors between

¹⁰Using the sample weight rather than the raw weight of each profession is important to adjust our measures for biases due to the presence of LLMA of unequal size and some of them particularly small (Borrelli et al. 2012).

¹¹More specifically, the availability of ICP variables avoid potential methodological problems which may arise when information referring to the American occupational structure (i.e., contained in the US O*Net repertoire) are matched with labour market data referring to different economies as the European ones. The existing literature on automation following Goos et al. (2014) and various recent papers on WFH in Italy, such as Boeri et al. (2020), use the US O*Net data and create a sophisticated, but imperfect, 'bridge' between US and European (and Italian in particular) occupations, which possibly reflects labour market features specific to the US. The analysis of characteristics and advantages of using the ICP survey when addressing Italian labour markets is offered in Bonacini et al. (2021b) and Barbieri et al. (2022) and Cirillo et al. (2020).

1 January 2009 and 30 June 2019.¹² The resulting CICO database consists in a matched employer-employee micro-level data for a total of around 19 million observations, providing information on the employee (identification code, year of birth, gender, citizenship, education level, region of birth, residence and work), the contract (start date, termination date, contract type, full/part time, professional qualification, reason for termination, collective labour agreement), the employer (identification code) and the sector of affiliation (Ateco 2007 classification, i.e. the Italian version of NACE Rev. 2).

Based on this dataset, we construct the number of contracts that expired between March and May 2019 as a percentage of employed workers at the LLMA level. Ideally, one would use the number of contracts expected to expire during the Spring 2020, however this information is not available yet. Thus, we resort to 2019 data as a reliable proxy building on the observed persistence in the variation of this variable across locations.

The last labour-market variable that we include is the percentage of active population taken from the 2011 population census. This variable can account for the different participation in the labour market across LLMAs, which can affect individual mobility as work was one of the reasons why individuals could move during the lockdown phase.

In addition to variables related to the labour market, we also include demographic and geographic controls that can influence individual mobility. Among the demographic controls, we include the population size in 2019 taken from Istat and the percentage of population aged 19 or under and that aged 65 or over, both taken from the 2011 population census. Moreover, we build a proxy for how the threat of contagion might have been perceived by the population using data on the excess mortality rate in the early months of 2020. The excess mortality rate, recorded by Istat, measures the rate of deaths in 2020 that is over and above the average values in the same months of previous 5 years.¹³ This variable is only available for about 90% of Italian municipalities, further reducing the overall sample at hand. Among the geographic variables, we include topographic characteristics, such as the surface in squared kilometres and the average altitude in metres, as well as an index from 0 to 5 for the importance of tourism in the local economy, all taken from Istat. All demographic and geographic variables are available at the municipality level and, where necessary, are aggregated at the LLMA level using local population weights.

¹²The data are collected by the Ministry directly from employers, since they are obliged to register the contract and provide all the information. After the collection of records, the latter are submitted, by the Ministry, to a validation procedure.

¹³It is worth noticing that the official figures on the exact number of deaths were made available by Istat only in the late Spring 2020, and could not be known by the public in early March. As shown by Cerqua et al. (2021), local estimates of the real death toll have proven to be problematic, in particular during the first phase of the pandemic. Yet, as newspapers and authorities informed the population about the available evidence on the number of deaths, patients in intensive care units, and people positive to the tests, one cannot rule out that several citizens might have had an idea about the incidence of the disease and noticed an extraordinarily high number of deaths.

4 March 9: lockdown of 26 protected areas

4.1 Methodology and descriptive statistics

To assess the direct impact of the lockdown measures in the “protected areas”, we design a research strategy exploiting the fact that the Italian government applied the lockdown treatment only to 26 very large geographical areas identified on the basis of pre-existing administrative boundaries at the NUTS-3 level, i.e., provinces. This implies that each province, affected by the lockdown or not, includes municipalities and local labour market areas that exhibit diversified social, economic and epidemiological conditions.

This condition makes it possible to design an empirical approach whereby the treatment, i.e., the lockdown, of individual municipalities can be considered as good as random. To identify the impact of the lockdown on mobility, in particular, we exploit the fact that 30% of the Italian LLMA cut across different provinces and focus the analysis on those LLMA that contain municipalities both within and outside the protected areas. This innovative approach allows us to exploit the discontinuity associated with the lockdown policy at the provincial border with a view to identifying the actual impact of the measures on individual mobility. Focusing on municipalities contiguous to the provincial boundary within a LLMA is theoretically and empirically sensible, as municipalities in a LLMA tend to exhibit characteristics that are homogeneously and smoothly distributed across treated and untreated areas, thereby reducing the impact of confounding factors. Moreover, we take advantage of the fact that the announcement of the lockdown measures and their substitution with nationwide measures took place unexpectedly and over only two days, preventing them from being anticipated by the public and manipulated by municipal authorities, thus ruling out spatial sorting effects that would confound the analysis.

From a methodological viewpoint, our approach borrows from previous works exploiting spatial discontinuity and policy-change boundaries to assess the impact of policy measures. Giua (2017), for instance, assesses the economic impact of the regional policy of the European Union by exploiting the administrative boundaries and a similar border strategy framework applied to the municipalities contiguous to the policy-change boundary. *Mutatis mutandis*, our approach shares with Goolsbee and Syverson (2021) an identification strategy that exploits differences within the same commuting zones but across state and county boundaries with different policy regimes. As in Goolsbee and Syverson (2021), one issue related to our identification strategy is that the control may be contaminated due to the shared labor market nature of our geographic units. That is, the control municipalities without a lockdown may be partially locked down due to workplaces and leisure venues in locked-down provinces that become not accessible by people in non-locked-down provinces but within the same LLMA. If present, this issue would create a bias towards zero, which implies that our findings would not be invalidated but, rather, they are likely to show a lower bound of the true effect.

Thus, our analysis considers all the municipalities that are contiguous to the policy-change boundary within the same LLMA. This implies that our sample consists of 606 municipalities belonging to 33 LLMA (as defined by Istat in 2011)

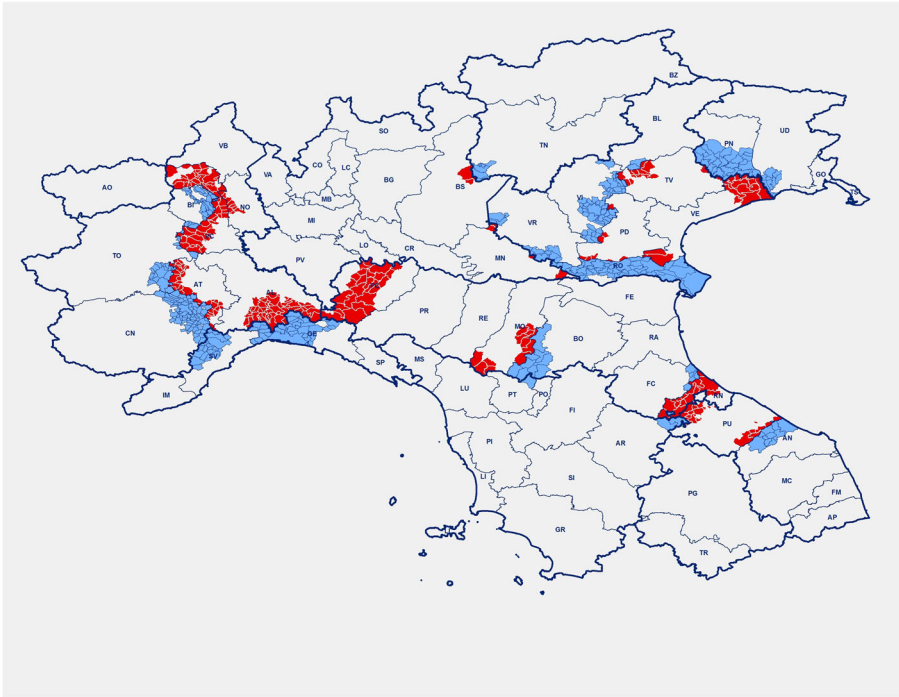


Fig. 4 Treated and untreated municipalities on March 9, Centre-North of Italy. Municipalities under lockdown on March 9: red; other municipalities: blue. Thicker lines represent borders of regions, while thinner lines represent borders of provinces (with province codes)

that include both treated (42%) and untreated (58%) municipalities (see Fig. 4 for a map).¹⁴

Before discussing our estimating equation, we examine the distributions of the municipal variation in individual mobility for the municipalities under lockdown and for the other municipalities, as plotted in Fig. 5. A cursory look at this graph makes it possible to draw three main observations. First, mobility tends to fall in most areas, either affected by the lockdown or not: as explained in the Introduction, this strengthens the case for elaborating a research design that allows us to distinguish the impact of the policy restrictions from other organisational and psychological effects affecting individual behaviour. Second, the distribution of the mobility values for the municipalities in the protected areas lies to the left of the distribution for the other municipalities, as one would expect. Third, although the majority of municipalities

¹⁴The sample would also include 9 municipalities for which data on mobility were not available due to the fact that these municipalities are too small for such data to be recorded in an anonymous way. Indeed, the largest one of these municipalities has only 206 residents.

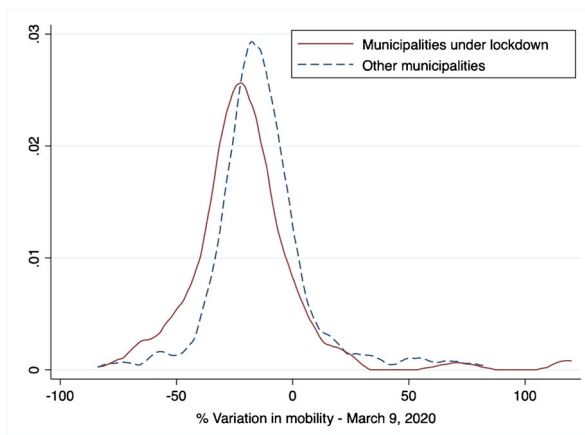


Fig. 5 Distribution of variation in mobility relative to January 13-February 16

record a negative change in mobility, the variation is large and some of them even present positive changes.¹⁵

Table 1 confirms that there exists a statistically significant difference in the mean change in mobility across the two groups of municipalities. The mean change in daily mobility over the sample of municipalities is about -16%, but it varies from the -20% in the areas under lockdown to -13% in the other areas.

More formally, our analysis aims to relate variations in mobility between March 9 and the average daily mobility in the period January 13-February 16 (dM_{9march}) to the policy treatment variable that takes value one for municipalities (within the same LLMA) located in the provinces subject to the lockdown and 0 otherwise. The functional form that we estimate, accordingly, is:

$$dM_{j,9March} = \gamma + \eta L_j + \mu_i + \epsilon_j, \quad (1)$$

where $dM_{j,9March}$ is the change in mobility in municipality j from the average daily mobility in the period January 13-February 16 to March 9, L_j is a dummy variable taking value one if the municipality j is in a province subject to the lockdown, μ_i is a fixed effect for LLMA i where municipality j is located, and ϵ_j is a random error.

To identify the parameter of interest, η , we exploit the policy variation across municipalities at the provincial border within the same LLMA while limiting the impact of other confounding factors. Accordingly, following the approach to study policy-change boundaries (see, for instance Giua 2017), we include fixed effects at the level of LLMA to control for all the characteristics that are invariant across municipalities within the same LLMA.

Notably, although a border strategy framework does not require to control for local covariates in the estimation to the extent that the policy treatment can be considered

¹⁵Although seemingly surprising, this finding can potentially be explained by a diversion effect, whereby unrestricted areas receive part of the traffic previously occurring in the restricted areas. Unfortunately, we cannot directly test this hypothesis and, thus, this is an interesting venue for further research in the future.

Table 1 Mean tests

	Lockdown areas	Other areas	Diff.	P-value
dM_{9March}	-20.150	-13.093	-7.057	0.000***

Notes: The sample includes 606 municipalities contiguous to the policy-change boundary within the same LLMA. *** $p < 0.01$

as good as random, we nonetheless include in the specifications also some control variables capturing possibly relevant differences across neighbouring municipalities in terms of demographic or geographic characteristics. This is simply meant to refine the estimation of the direct impact of the localized March 9 lockdown, given that the validity of the identification strategy stays in the exogeneity of the policy treatment across municipalities contiguous to the policy change. As explained above, our identification strategy is indeed motivated by the fact that the government selected the lockdown areas using a large geographical scale (e.g., one region and various provinces in three other regions) and this rules out any relevant statistical relationship between the adoption of the lockdown and the characteristics of the municipalities contiguous to the provincial border, and even more so within the same LLMA.

Admittedly, the inclusion of LLMA fixed effects does not make it possible to encompass any of the controls calculated only at the LLMA level. This implies that the three indicators of occupations' characteristics (occupations' exposure to transmittable diseases, the need for physical proximity on the job, and the feasibility of WFH) and the proxy for the share of fixed-term contracts expiring in the lockdown period cannot be directly analysed. However, this does not represent a problem for the investigation of the March 9 lockdown as these features are theoretically less relevant for the lockdown than for the opening up phase. Differently from the gradual and differentiated removal of mobility and sectoral restrictions imposed after March 25, the March 9 lockdown was indeed implemented overnight, unexpectedly (as it was the first intervention of this kind in any advanced economy) and designed to cover every person independently from her occupation and economic activity. In addition, it was not accompanied by measures to facilitate WFH. Accordingly, while it is appropriate to investigate whether the recovery in mobility is associated with the features of local labour markets, as we shall do in Section 5, these latter are less relevant for the impact of the lockdown.

Moreover, we offer some additional empirical evidence corroborating the tenet that the lockdown can be treated as good as random. We regress the excess mortality rate that occurred in March and April 2020 on the lockdown dummy so as to verify whether the treatment is correlated with government's real-time confidential information on the number of patients who were seriously ill in January and February and eventually died by the end of April. The regressions also include fixed effects at the LLMA level for consistency. The results indicate that the treatment dummy had no statistically significant effect on the excess mortality rate (p -value = 0.375), which provides further evidence in favour of the fact that the lockdown can be considered exogenous.

4.2 Results

Table 2 reports a set of results based on the estimation of Eq. 1 where the change in mobility between March 9 and the average daily mobility in the period January 13-February 16 is regressed on the policy lockdown dummy and a number of local controls, including LLMA fixed effects. Among the controls at the municipal level, we include the activity rate, population size, the percentage of residents aged 19 or under, the percentage of residents aged 65 or above, surface size, altitude and an index for the importance of tourism in the local economy. (The full set of results including the coefficients for all the additional controls can be found in Appendix A.) In the last column, we also include the excess mortality rate among the controls. It is worth noticing that the observations on the excess mortality rate for the first two months of the year reduce the overall sample by 10%. Thus, we present separately the estimations with and without this variable.

The results in Table 2 show that, even when controlling for a number of observables at the municipal level and for the unobserved effects at the LLMA level, the average negative impact of the lockdown on local mobility is just over 7 percentage points. This is 50% more than the decrease in mobility recorded in the control areas.

This figure is in line with the results found by Brzezinski et al. (2020), Dave et al. (2020a), Engle et al. (2020), Goolsbee and Syverson (2021), and Lyu and Wehby (2020) for the stay-at-home orders in the US. This finding suggests that the observed decline in mobility after the localized lockdown should not be considered as the result of different levels of awareness and fear in the population across municipalities, in turn motivated by higher death rates and the like, but the pure and direct effect of the localized restrictive measures adopted by the government on March 8. This corroborates the idea that individual mobility was directly and immediately affected by the

Table 2 Effect of localized lockdown on changes in mobility, March 9: baseline

	(1)	(2)	(3)
Lockdown	-7.107*** (2.676)	-7.453*** (2.717)	-7.741*** (2.789)
Excess mortality rate, Jan-Feb			0.722 (1.213)
Controls	No	Yes	Yes
Observations	606	602	538
R-squared	0.144	0.177	0.191
F-stat	7.052	3.717	3.230

Notes: The sample includes the municipalities contiguous to the policy-change boundary within the same LLMA. The dependent variable is the variation in mobility on March 9 relative to January 13-February 16 at the level of municipalities. The controls include: participation rate in percentage, population size in 2019 (logs), percentage of residents aged 19 or under, percentage of residents aged 65 or over, surface size in squared kilometres (logs), altitude in metres (logs), and tourism index (0-5). All specifications shown include LLMA fixed effects. *** $p < 0.01$

restrictive measures imposed, even though for just one day, by the Italian authorities on this limited number of provinces located in the Centre-North of Italy.

Next, to account for possible different degrees of mobility in certain municipalities, we show that the results presented above are robust to changes in the sample. Table 3 shows the results based on adjustments to the baseline sample. In Columns (1) and (2), respectively, we winsorise and trim the top and bottom 5% of observations so as to verify that outliers are not driving the results. In Column (3) we exclude all the municipalities that exhibit positive changes in mobility despite being subject to the lockdown measures. Column (4) takes into account the existence of municipalities that, according to Istat, are the “centre” (*capoluogo*) of a LLMA. In Column (5) and (6), respectively, we exclude the top and bottom 5% of municipalities in terms of population. Finally, in Column (7) we restrict the sample to those municipalities that directly touch a border between two provinces that differ depending on the lockdown policy. On one hand, this robustness check has the advantage that we directly compare nearby municipalities, which makes our treatment and control groups even more related to each other. On the other hand, this approach potentially biases results further towards zero because the control group may be more contaminated by the treatment group. Nonetheless, our results are confirmed across all these checks.

The last set of empirical tests we offer in this section is a set of placebo experiments to strengthen the causal interpretation we give to our findings. In Column (1) of Table 4, we look at the changes in mobility measured on March 1, before the localized lockdown was adopted in the 26 provinces. In Column (2), we consider the change measured on March 30, after the adoption of the new nationwide measures on mobility and the suspension of most economic activities (as discussed in Section 2). The estimations for the changes in mobility measured on May 4, at the beginning of the re-opening phases, are reported in Column (3). We expect not to find a significant coefficient in any of these cases. Indeed, in the first case, there was still little awareness of the diffusion of the pandemic in Italy. On the second date, the new restrictive measures covered equally all the municipalities in the country, with no discontinuity

Table 3 Effect of localized lockdown on changes in mobility, March 9: robustness checks

	Winsor 5% (1)	Trim 5% (2)	$dM < 0$ (3)	No centres (4)	No top 5% (5)	No bot 5% (6)	Contiguous (7)
Lockdown	-5.982*** (1.917)	-5.090*** (1.616)	-9.718*** (2.346)	-7.449*** (2.839)	-7.545*** (2.853)	-7.350*** (2.628)	-5.442** (2.377)
Observations	602	544	574	569	570	571	266
R-squared	0.186	0.192	0.199	0.181	0.180	0.165	0.468
F-stat	2.187	1.837	2.918	3.550	3.523	2.556	2.375

Notes: The sample includes the municipalities contiguous to the policy-change boundary within the same LLMA. The dependent variable is the variation in mobility on March 9 relative to January 13-February 16 at the level of municipalities. All specifications include LLMA fixed effects and controls for participation rate in percentage, population size in 2019 (logs), percentage of residents aged 19 or under, percentage of residents aged 65 or over, surface size in squared kilometres (logs), altitude in metres (logs), and tourism index (0-5). ** $p < 0.05$; *** $p < 0.01$

Table 4 Effect of localized lockdown on changes in mobility: placebo

	March 1 (1)	March 30 (2)	May 4 (3)
Lockdown	-2.854 (3.316)	-4.042 (2.927)	1.813 (3.101)
Observations	605	600	605
R-squared	0.151	0.187	0.192
F-stat	1.172	7.042	8.125

Notes: The sample includes the municipalities contiguous to the policy-change boundary within the same LLMA. The dependent variable is the variation in mobility relative to January 13-February 16 at the level of municipalities. All specifications include LLMA fixed effects and controls for participation rate in percentage, population size in 2019 (logs), percentage of residents aged 19 or under, percentage of residents aged 65 or over, surface size in squared kilometres (logs), altitude in metres (logs), and tourism index (0-5)

at provincial borders. In the third case, inter-regional restrictions were still in force while authorities started removing intra-regional restrictions. In none of these cases, the coefficient of the policy treatment is significantly different from zero.¹⁶ These placebo experiments show that the March 9 lockdown measures on 26 provinces help to explain only the observed changes in mobility occurred the day after their announcement and not other changes that predate or follow these announcements.

5 June 3: re-opening

5.1 Methodology and descriptive statistics

Next, we analyse the opening-up phase and, thus, focus on how the effects of the lifting of the measures on mobility are associated with the characteristics of the local labour market areas. In this case, we cannot rely on the same research strategy described above as the restrictions were lifted simultaneously for the entire country. As no control group is available, we consider all the LLMA and our aim is to explore, via a cross-sectional analysis, to what extent mobility patterns differed according to the characteristics and the composition of the local labour force and other local factors.

To address this issue, we estimate the following functional form:

$$dM_{i,3june} = \alpha + \beta X_i + \delta Z_i + \epsilon_i, \quad (2)$$

where $dM_{i,3june}$ is the change in mobility in LLMA i on June 3, X_i is a matrix of local (predetermined) factors related to the characteristics and the composition of the local labour force that may potentially impact on mobility, Z_i is a matrix of covariates

¹⁶The small changes in the samples are due to the time-varying availability of municipal data on individual mobility across dates.

accounting for demographic and geographical characteristics and local amenities, and ϵ_i is a random error.

The dependent variable is the variation in mobility on June 3, that is after the re-opening phase and, in particular, on the day in which people in Italy were allowed to move again across regions. We use two different ways to construct our dependent variable. The first way calculates the percentage change in mobility on June 3 relative to the baseline period, that is the average mobility between January 13 and February 16. This is the same way mobility changes were calculated following the localized lockdown on March 9. As no figures on the levels of mobility for the baseline period are provided, we cannot add any additional control for that. The second way calculates the percentage change in mobility on June 3 relative to March 30, that is the first working day of the week when both the restrictions on individual movements and the sectoral lockdown were concurrently implemented nationwide and when individual mobility saw its largest decrease on average. In this case, we add the change in mobility on March 30 relative to the baseline period among the regressors to account for mean reversal processes.

Among the variables in X , we consider three indicators that refer to the exposure to the risk of contagion, the suitability of occupations to be performed remotely, and the relative importance of tasks requiring physical proximity. Among the characteristics of LLMA and their labour force, we include the percentage of fixed-term contracts that expired during the period March-May 2019 over the total number of employed workers to proxy for the number of contracts expiring during the nationwide lockdown period and to take into account the importance of fixed-term contracts in local labour markets, and the percentage of active people over the total population. All these variables, related to the characteristics of the local labour force, are considered exogenous as they are measured well before the outbreak of the pandemic and the restrictions were put in place.

Table 5 Summary statistics, LLMA level

	Mean	St. dev.
Disease exposure	8.921	3.006
Remote work feasibility	46.948	2.642
Physical proximity	55.214	3.091
Fixed-term contracts expired, %	3.254	9.691
Participation rate, %	49.788	5.051
Population 2019, log	11.009	1.055
Residents < 19 years, %	18.517	2.311
Residents > 65 years, %	21.566	3.243
Excess mortality rate	0.108	0.266
Surface squared km, log	6.069	0.731
Altitude metres, log	5.111	1.200
Tourism index	3.175	1.057

Notes: The number of observations is 462

Matrix Z includes a set of controls for demographic and geographical characteristics and local amenities that do not relate to labour markets. In particular, it includes the log of the size of the local population in 2019, the percentage of local residents aged 19 or under and that aged 65 or over, the excess mortality rate in the period January-May 2020 to proxy for the local spread of COVID-19, the log of the size of the local area in squared kilometres, the log of the altitude in metres, and an index for the touristic attractiveness and importance of an area. Summary statistics for all the regressors included in this analysis are provided in Table 5.

5.2 Results

Table 6 shows the determinants of variations in mobility after re-opening on June 3. The first two columns use the percentage change in mobility on June 3 relative to the baseline period, that is the average mobility between January 13 and February 16, while the last two columns use the percentage change in mobility on June 3 relative to March 30. In addition to the set of variables included in matrix X related to the characteristics of local labour markets, Table 6 also includes region fixed effects in two specifications (columns 2 and 4). This is to account for unobservable differences across regions in the population, the structure of local economies and other features (e.g., weather) that can correlate with mobility patterns but cannot be measured at a more disaggregated level.

Table 6 Determinants of the extent of the recovery in local mobility after re-opening, June 3: baseline

	wrt Jan 13-Feb 16		wrt Mar 30	
	(1)	(2)	(3)	(4)
Mobility changes, March 30			-0.809*** (0.054)	-0.757*** (0.064)
Disease exposure	-0.607*** (0.176)	-0.471*** (0.176)	-0.650*** (0.171)	-0.486*** (0.168)
Remote work feasibility	-0.972*** (0.242)	-1.082*** (0.240)	-0.836*** (0.239)	-0.953*** (0.234)
Physical proximity	-0.251 (0.189)	-0.303 (0.186)	-0.173 (0.189)	-0.198 (0.189)
Fixed-term contracts expired, %	-0.714*** (0.058)	-0.673*** (0.062)	-0.648*** (0.055)	-0.599*** (0.059)
Participation rate, %	-0.649*** (0.110)	-0.448** (0.211)	-0.659*** (0.108)	-0.364* (0.215)
Region fixed effects	No	Yes	No	Yes
Observations	462	462	462	462
R-squared	0.423	0.495	0.451	0.525
F-stat	52.26	17.37	66.72	20.27

Notes: The dependent variable is the variation in mobility on June 3 relative to January 13-February 16 (columns 1 and 2) or March 30 (columns 3 and 4) at the level of LLMA. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

We find that LLMA with an economic structure characterised by a higher proportion of professions exposed to diseases and infections exhibit a significantly smaller increase in mobility after re-opening. This result is in line with our hypothesis as the fear of contracting COVID-19 and the measures imposed on the workplace to minimise such risk have led many people to continue staying at home. It also confirms that the index of risk exposure to diseases and infections is higher among professions that could not stop during the lockdown: thus, it is logical to expect that the recovery of mobility will be lower where there is a higher incidence of such a risk. In addition, the effect of disease exposure becomes somewhat smaller when we include region fixed effects. This is possibly due to the fact that different LLMA within a region and, more generally, nearby areas tend to exhibit similar economic structures.

The results also show a negative and significant relation between remote work feasibility and mobility. Thus, LLMA characterised by professions more suitable for flexible work arrangements exhibit lower mobility patterns relative to LLMA with occupations less suitable for remote work when mobility restrictions are lifted. Indeed, by June, remote work had become more standard in Italy (Bonacini et al. 2021b) and employees who could work from remote were still taking advantage of this possibility both to avoid outside contacts in fear of contracting COVID-19 and to take care of children who were still attending school remotely. On the other hand, having an economic structure that favours professions that require physical proximity does not correlate with mobility patterns after re-opening.

With regards to the other variables related to local labour markets, we find that LLMA with a higher percentage of fixed-term contracts that expired during the period March-May 2019 exhibit lower increases in mobility. We hypothesise that this is due to the fact that the use of fixed-term contracts in a given LLMA is persistent over time and such contracts were not covered by the furlough scheme adopted by the Italian government. Thus, when the pandemic hit and the lockdown came in place, most fixed-term contracts expiring during that period were not renewed with negative consequences on employment and mobility.

The participation rate also shows a negative and significant relation to mobility, although its significance decreases when regional fixed effects are included. Thus, LLMA with higher participation rates tend to exhibit smaller increases in mobility after re-opening. This seems to be a surprising result as we possibly expect that areas with a higher activity rate, and thus with more people going to work or looking for a job, also show higher increases in mobility. However, the result is not too surprising if we think that during the lockdown only people who had to move for work (as well as for health or emergencies) could do so; accordingly, local mobility remained higher after the nationwide lockdown where the local population was more involved in the productive activities. Thus, this negative estimated relation suggests that after re-opening there was a catching-up effect, whereby people from areas with more inactive population could start moving again.

With regards to mobility changes on March 30, the coefficient in the last two specifications is negative and significant. We can interpret this result as equivalent to mean reversal, that is in the areas in which the lockdown and the restrictive measures had a particularly strong impact on mobility by the end of March, people started to move more in the period following the re-opening.

All the above results do not differ much across specifications and, in particular, they are not affected significantly by whether we look at the changes in mobility on June 3 relative to the period pre-COVID-19 (our baseline) or relative to March 30. This is probably related to the fact that the decrease in mobility due to the nationwide restrictions put in place to fight the COVID-19 pandemic was rather homogeneous across LLMAs, while the increase in mobility following the opening-up phases exhibited a more heterogeneous process related to the characteristics of local labour markets interacted with the possible fear of contracting COVID-19. In part, this difference can also be observed in the additional results below (Table 8).¹⁷

Next, we run some specifications to study whether our main results are robust to the inclusion of additional controls that do not regard the labour markets. Column (1) of Table 7 corresponds to the column (4) of Table 6 for easier comparison. While column (2) adds demographic controls, in particular population size, the percentage of the population aged 19 or under and that aged 65 or over and the excess mortality rate in the period January-May 2020, column (3) adds geographic controls, in particular the surface size, the altitude and the attractiveness and importance of tourism.

The results show that the coefficients on variables related to the characteristics of the local labour force do not differ significantly across specifications, although the coefficients on disease exposure and remote work feasibility become significant at the 5% level. With regards to the other controls, less populated and larger areas, and those with a greater incidence of people aged between 19 and 65 exhibit larger increases in mobility after the re-opening phase. This could be related to the fact that people in more isolated areas were less likely to run into other people and, thus, were less afraid to move around.

In commenting our results, we refrained from interpreting them in causal terms. In fact, we cannot employ an identification strategy as strong as that used in the first part of the analysis and we cannot rule out that there exist other unobserved relationships confounding our results. Notwithstanding the efforts to introduce as many controls as possible, we cannot exclude that some latent variables are correlated with both mobility and the explanatory variables of interest. The degree of compliance with the law, for instance, exhibits differentiated regional patterns, and to the extent that it correlates both with mobility and with other labor market-related variables, its omission may confound the estimates. Other potentially relevant factors are the political stance of local authorities, the positions taken by local media, and the presence (or lack thereof) of transport infrastructures.

Finally, we examine changes in mobility patterns on other dates that are part of the re-opening period. In addition to June 3 (i.e., free inter-regional mobility), we look at May 4 (i.e., beginning of Phase 2), May 18 (i.e., free mobility between municipalities within the same region), and June 15 (i.e., beginning of Phase 3). This analysis can provide further evidence in favour of the fact that the heterogeneous mobility patterns are associated with the re-opening phase.

Table 8 shows the results of these additional regressions in chronological order. Column (3) reports the same results as column (3) of Table 7 to compare more easily

¹⁷It is worth noticing that these findings are not in contrast with those offered in Section 4, where we focus on the impact of localized, and not nationwide, mobility restrictions.

Table 7 Determinants of the extent of the recovery in local mobility after re-opening, June 3: robustness checks

	Baseline (1)	Demo controls (2)	Geo controls (3)
Mobility changes, March 30	-0.757*** (0.064)	-0.794*** (0.077)	-0.816*** (0.084)
Disease exposure	-0.486*** (0.168)	-0.381** (0.170)	-0.400** (0.172)
Remote work feasibility	-0.953*** (0.234)	-0.708*** (0.261)	-0.608** (0.269)
Physical proximity	-0.198 (0.189)	-0.182 (0.198)	-0.134 (0.194)
Fixed-term contracts expired, %	-0.599*** (0.059)	-0.646*** (0.057)	-0.665*** (0.062)
Participation rate, %	-0.364* (0.215)	-0.686** (0.279)	-0.780*** (0.280)
Population 2019, log		-1.668*** (0.585)	-3.085*** (0.928)
Residents < 19 years, %		-1.255* (0.663)	-1.203* (0.648)
Residents > 65 years, %		-1.442*** (0.488)	-1.686*** (0.486)
Excess mortality rate		-2.567 (2.825)	-1.899 (2.824)
Surface squared km, log			2.651** (1.026)
Altitude metres, log			0.131 (0.612)
Tourism index			0.724 (0.671)
Observations	462	462	462
R-squared	0.525	0.543	0.555
F-stat	20.27	19.22	17.90

Notes: The dependent variable is the variation in mobility on June 3 relative to March 30 at the level of LLMA. All specifications include region fixed effects. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

the changes in the coefficients over time. The effects of the two significant indicators for the composition of the local labour force based on disease exposure and remote work feasibility lose their significance when we look at mobility changes occurred in May. In the same way, the participation rate becomes a significant determinant of mobility changes only in June. On the other hand, the significance of the demographic and geographic variables does not seem to change much between May and June. These results suggest that the removal of restrictions over time interacted

Table 8 Determinants of the extent of the recovery in local mobility after re-opening: May vs June

	May 4 (1)	May 18 (2)	June 3 (3)	June 15 (4)
Mobility changes, March 30	-0.477*** (0.061)	-0.588*** (0.060)	-0.816*** (0.084)	-0.824*** (0.089)
Disease exposure	-0.179 (0.118)	-0.270* (0.151)	-0.400** (0.172)	-0.514** (0.210)
Remote work feasibility	-0.319* (0.190)	-0.379* (0.223)	-0.608** (0.269)	-0.433 (0.321)
Physical proximity	0.0402 (0.168)	0.163 (0.203)	-0.134 (0.194)	0.367 (0.240)
Fixed-term contracts expired, %	-0.313*** (0.046)	-0.490*** (0.048)	-0.665*** (0.062)	-0.600*** (0.055)
Participation rate, %	0.0291 (0.210)	-0.441* (0.235)	-0.780*** (0.280)	-1.322*** (0.377)
Population 2019, log	-1.600** (0.673)	-1.354* (0.755)	-3.085*** (0.928)	-5.015*** (1.052)
Residents < 19 years, %	0.623 (0.431)	-0.00784 (0.539)	-1.203* (0.648)	-1.773** (0.795)
Residents > 65 years, %	-0.790** (0.361)	-1.552*** (0.435)	-1.686*** (0.486)	-3.099*** (0.609)
Excess mortality rate	2.565 (2.326)	0.588 (2.189)	-1.899 (2.824)	-7.100** (2.948)
Surface squared km, log	2.103*** (0.780)	1.542* (0.883)	2.651** (1.026)	2.432* (1.324)
Altitude metres, log	-0.432 (0.390)	-0.300 (0.399)	0.131 (0.612)	-0.669 (0.592)
Tourism index	-1.870*** (0.491)	-1.153** (0.553)	0.724 (0.671)	3.393*** (0.943)
Observations	462	462	462	462
R-squared	0.485	0.592	0.555	0.522
F-stat	14.75	24.48	17.90	14.25

Notes: The dependent variable is the variation in mobility on May 4, May 18, June 3 or June 15 relative to March 30 at the level of LLMA. All specifications include region fixed effects. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

with the characteristics of local labour markets to produce heterogeneous changes in mobility patterns following the COVID-19 pandemic.

6 Closing remarks

This work aims to improve our understanding of the determinants of local mobility patterns following the COVID-19 pandemic in Italy. First, it aims to identify empirically the contribution of the localized mobility restrictions imposed on 26

provinces on March 9, 2020, on the reduction of individual mobility. Second, it assesses to what extent the recovery of mobility patterns after the lifting of the nationwide restrictive measures is related to the characteristics of local labour markets. By adopting two complementary empirical approaches to tackle empirically these connected issues, we exploit the remarkable territorial variation in mobility patterns across municipalities and local labour market areas, as well as the evolution of policy restrictions in Italy over time.

By exploiting the unexpected and localized travel ban applied overnight in 26 provinces in the Centre-North of the country on March 9, we show that the restrictive measures lowered individual mobility by 7 percentage points, on top of the reduction in mobility (by 13 percentage points) recorded in the adjacent areas that were not affected by the measures. These findings confirm the estimated magnitude of the impact of stay-at-home orders found for the US in previous works, but based on a truly exogenous research design that exploits unanticipated restrictions imposed by the central government on large geographical areas as well as geographically disaggregated data, which in turn allow us to look at neighboring municipalities within the same LLMA's spanning across provinces facing different restrictive measures.

With regards to the lifting of the nationwide policy measures in early June, our results are the first to shed light on how the recovery in local mobility is related to the composition of the local labour force, the characteristics of the occupations, and other local demographic characteristics. We show that the ability to work from home, the local share of professions exposed to the risk of contagion, the local share of expired fixed-term contracts (that could not be frozen by the Italian furlough scheme) and the local activity rate appear all to be negatively related to the observed changes in mobility once the lockdown was lifted.

Our results bear on policymakers along two dimensions. First, they confirm that unanticipated localized restrictions on individual mobility are effective tools to contain the circulation of people and, arguably, of the virus. While previous studies focusing on the U.S. have concluded that self-imposed restrictions, spontaneously adopted out of fear and reciprocity, might have produced outcomes similar to those induced by travelling bans and stay-at-home orders, our results indicate that exogenous, unanticipated and localized restrictive measures alter individual mobility on top and above what is due to individual decisions. Second, our findings warn the authorities to consider carefully how the removal and softening of nationwide restrictions may interact with the characteristics of local economies and labour markets. The evidence we provide in this paper suggests that the lifting of such restrictive measures could be tailored to the local features if the interest of the authorities is in producing more geographically homogeneous effects. While many countries are now designing the new labor market in the post-COVID age, our results also imply that the return to pre-pandemic mobility patterns may proceed at different speed rates in different labor market areas, thereby leading to a prolonged period of adjustment that may amount, at least temporarily, to a 'new normal'.

These policy recommendations are particularly important in light of the fourth wave of the pandemic that several countries are facing at the time of writing due to the greater contagiousness of the Omicron variant. Indeed, epidemiologists and other experts have been warning that, despite the diffusion of vaccines and drugs,

the authorities must be prepared to introduce restrictive measures so as to limit the diffusion of the pandemic. Following these warnings, localized restrictions are currently being imposed in several municipalities, but further restrictions may come along if the orange alert level is reached at the regional level. In this context, our findings suggest that the interaction between the imposition and the removal of localized mobility restrictions and the characteristics of the local labour markets should be considered very carefully, as the socio-economic impact of such restrictions may be highly heterogeneous due to the pre-existing features of the local labour markets. This recommendation is supported by recent evidence provided, among others, by Cerqua and Letta (2022) who advocate a place-based policy response to address the uneven economic geography of the pandemic.

Appendix A: Full Results from Section 4

Table 9 Effect of lockdown on changes in mobility, March 9: baseline

	(1)	(2)	(3)
Lockdown	-7.107*** (2.676)	-7.453*** (2.717)	-7.741*** (2.789)
Participation rate, %		-0.512 (0.419)	-0.445 (0.443)
Population 2019, log		-0.376 (1.367)	-0.413 (1.462)
Residents < 19 years		0.149 (0.690)	-0.245 (0.744)
Residents > 65 years		0.530 (0.508)	0.453 (0.545)
Surface squared km, log		-1.325 (1.898)	-1.102 (1.965)
Altitude metres, log		-0.069 (1.777)	-0.069 (1.810)
Tourism index		0.045 (0.676)	0.041 (0.723)
Excess mortality rate, Jan-Feb			0.722 (1.213)
Observations	606	602	538
R-squared	0.144	0.177	0.191
F-stat	7.052	3.717	3.230

Notes: The sample includes the municipalities contiguous to the policy-change boundary within the same LLMA. The dependent variable is the variation in mobility on March 9 relative to January 13-February 16 at the level of municipalities. All specifications include LLMA fixed effects. *** $p < 0.01$

Table 10 Effect of lockdown on changes in mobility, March 9: robustness checks

	Winsor 5%	Trim 5%	$dM < 0$	No centres	No top 5%	No bot 5%	Contiguous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lockdown	-5.982*** (1.917)	-5.090*** (1.616)	-9.718*** (2.346)	-7.449*** (2.839)	-7.545*** (2.853)	-7.350*** (2.628)	-5.442** (2.377)
Participation rate, %	-0.291 (0.296)	-0.237 (0.256)	-0.166 (0.366)	-0.475 (0.433)	-0.505 (0.433)	-0.311 (0.426)	-0.117 (0.521)
Population 2019, log	-0.559 (0.964)	-1.316 (0.821)	1.025 (1.182)	-0.219 (1.579)	0.069 (1.547)	-1.497 (1.384)	0.192 (1.788)
Residents < 19 years	0.308 (0.487)	0.371 (0.449)	-0.041 (0.611)	0.116 (0.713)	0.110 (0.713)	-0.494 (0.740)	1.365 (0.942)
Residents > 65 years	0.172 (0.358)	-0.052 (0.317)	0.140 (0.448)	0.604 (0.528)	0.592 (0.527)	0.169 (0.535)	-0.329 (0.674)
Surface squared km, log	-0.766 (1.339)	0.308 (1.124)	-2.623 (1.648)	-1.224 (1.997)	-1.420 (2.004)	0.050 (1.851)	0.222 (2.512)
Altitude metres, log	-0.407 (1.254)	-0.487 (1.027)	-0.872 (1.535)	-0.320 (1.979)	-0.427 (2.017)	-0.837 (1.688)	-1.052 (2.033)
Tourism index	-0.150 (0.477)	-0.231 (0.409)	-0.513 (0.599)	0.122 (0.704)	0.092 (0.703)	0.066 (0.664)	-0.373 (0.804)
Observations	602	544	574	569	570	571	266
R-squared	0.186	0.192	0.199	0.181	0.180	0.165	0.468
F-stat	2.187	1.837	2.918	3.550	3.523	2.556	2.375

Notes: The sample includes the municipalities contiguous to the policy-change boundary within the same LLMA. The dependent variable is the variation in mobility on March 9 relative to January 13-February 16 at the level of municipalities. All specifications include LLMA fixed effects. ** $p < 0.05$; *** $p < 0.01$

Table 11 Effect of lockdown on changes in mobility: placebo

	March 1 (1)	March 30 (2)	May 4 (3)
Lockdown	-2.854 (3.316)	-4.042 (2.927)	1.813 (3.101)
Participation rate, %	-0.035 (0.502)	-0.354 (0.445)	-0.740 (0.474)
Population 2019, log	-2.387 (1.648)	-4.109*** (1.474)	-5.203*** (1.549)
Residents < 19 years	-1.077 (0.799)	-1.373* (0.724)	-0.979 (0.780)
Residents > 65 years	-1.136* (0.584)	-0.114 (0.542)	-0.357 (0.566)
Surface squared km, log	2.019 (2.304)	1.089 (2.042)	0.918 (2.165)
Altitude metres, log	0.439 (2.158)	1.199 (1.909)	2.309 (2.028)
Tourism index	0.420 (0.810)	-0.154 (0.726)	0.206 (0.762)
Observations	605	600	605
R-squared	0.151	0.187	0.192
F-stat	1.172	7.042	8.125

Notes: The sample includes the municipalities contiguous to the policy-change boundary within the same LLMA. The dependent variable is the variation in mobility on each date relative to January 13–February 16 at the level of municipalities. All specifications include region fixed effects. * $p < 0.1$; *** $p < 0.01$

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Declarations

Conflict of Interests The authors declare that they have no conflict of interest.

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