Mobility in times of pandemics: Evidence on the spread of COVID19 in Italy's labour market areas ☆

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A R T I C L E   I N F O

A B S T R A C T

We investigate the interplay between the local spread of COVID-19 and patterns of individual mobility within and across self-contained geographical areas. Conceptually, we connect the debate on regional development in the presence of shocks with the literature on spatial labour markets and address some research questions about the role of individual mobility in affecting the spread of the disease. By looking at granular flows of Facebook users moving within and across Italian labour market areas (LMAs), we analyse whether their heterogeneous internal and external mobility has had a significant impact on excess mortality. We also explore how individual mobility plays different roles in LMAs hosting industrial districts – characterised by a thicker local labour market and denser business and social interactions – and with a high presence of "essential sectors" - activities not affected by the COVID-19 containment measures taken by the Italian government at the onset of the crisis.

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1. Introduction

The functioning, adaptation and transformative behaviour of spatial labour markets are intimately influenced by the perturbations and fluctuations that characterise modern complex economies in a geographical context (Pike et al., 2010; Simmie and Martin, 2010). Prior to COVID-19, other major challenges already impacted and reshaped the spatial structure, composition and features of labour markets, ranging from automation, technological change and the green transition to the financial crisis, sustained cross-border migration flows, and recent political developments of international importance (e.g. Brexit) (OECD, 2020). The coronavirus pandemic, nevertheless, represents an unprecedented health disaster with profound economic and geographical implications (Bailey et al., 2020). In a spatial perspective, it is a compelling fact that its incidence exhibits pronounced uneven patterns and, in this new and unanticipated scenario, the labour market mechanisms that underpin such a geographical unevenness fundamentally remain a black-box.

Understanding how local labour systems are related to the perturbation caused by the pandemic, and to the various lockdown measures that have followed, represents an open research issue and a key policy milestone to address the structural change that COVID-19 is posing also at the local level. In this setting, the combination of the literature on spatial labour markets and on regional economic change and development provides a fruitful interpretative key to investigate the interplay between COVID-19 and labour market dynamics (Martin et al., 2016; Gong et al., 2020). Moreover, since the patterns of individual mobility constitute the primary channel connecting labour markets and the spatiality of COVID-19, the conceptualisation of the sub-national space should follow functional – rather than merely administrative – lines, in such a way that the notion of spatial labour markets and its implications can be fully and appropriately accounted for. Concretely, this requires a shift from the analysis based on administrative regions towards an approach informed by Local Market Areas (LMAs). These offer a systemic way of capturing the mobility of individuals within and across spatial units, by attributing a key functional role to geographical space.

Based on this framework, the present paper specifically aims at investigating the interplay between the local spread of COVID-19 and the dynamics of local labour markets based on the patterns of individual mobility. Specifically, we first discuss the connections between regional development, COVID-19 and mobility within and across labour markets. Subsequently, by looking at very granular flows of people in Italian LMAs during the outbreak and the lockdown, we analyse whether their heterogeneous internal mobility has had a significant impact on the internal spread of the virus and under which circumstances they have actually behaved as self-containing local systems or have rather exported/imported people (and possibly) infections to/from other labour markets.

We employ data on excess mortality by LMAs taken from Cerqua et al. (2020); these data were estimated through Machine Learning techniques in order to generate a counterfactual scenario of mortality in the absence of COVID-19 rather than merely comparing mortality of 2020 with that of previous years, thus obtaining more reliable mortality data. Furthermore, as an important added value, we use Facebook Disease Prevention Maps data on the movement of people. This novel database provides very high-frequency data (three observations per day) that track Facebook users' movements. From these data we calculate measures of intra-LMA flows, inflows from other LMAs and outflows to other LMAs. We also extend the analysis by exploring how individual mobility plays different roles for different typologies of LMAs. Specifically, we focus first on labour systems hosting industrial districts, which are supposed to have a thicker local labour market and denser business and social interactions, and second on LMAs with a high percentage of "essential sectors", i.e. activities not affected by the COVID-19 containment measures implemented by the Italian government at the onset of the crisis.

With this in mind, while increasing our still scant knowledge about the geography of COVID-19, this research contributes to the academic debate on the role of LMAs in filtering the spread of COVID-19 through individual mobility. This is relevant when evaluating the evolution and functioning of spatial labour markets in the face of the pandemic, as our analysis unveils a number of conditions catalyzing their asymmetric capacity to contain (health) disasters. Moreover, the case of Italy is interesting for a number of reasons: first, it was the first EU country hit by the coronavirus, thus recording a large number of cases; second, it was also the first to adopt extensive lockdown measures at the country level, including the closure of a large number of economic activities throughout the country and the limitation of people's freedom to move; last but not least, the coverage of testing for coronavirus cases in Italy is among the highest and most geographically detailed, thus reassuring on the quality of data on the spatial incidence of the pandemic.

2. Mobility, labour market areas and COVID-19

Although the literature on regional development in the context of shocks is to date abundant (Martin, 2018), the perturbation brought about by the burst of the COVID-19 has very special characteristics, which make its analysis in need of different, and possibly new, conceptual and empirical tools (Gong et al., 2020). First of all, while the shock is global - like the 2008/2009 financial crisis that caused a boom in the number of studies on the capacity of regions to bounce back and/or adapt to new economic conditions (e.g. Webber et al., 2018; Sensier et al., 2016; Davies, 2011) - it is a pandemic. As such, it is different in nature from other shocks to which the literature on regional development normally refers to (e.g. Joo et al. 2019; Kim et al. 2017; Beutels et al., 2009; Zeng et al. 2005). The special features of a pandemic entails an array of structural aspects of which we still have little knowledge. This is particularly the case of the "risk"

places potentially face of being hit by the shock. In addition to the local economic conditions normally investigated when dealing with other types of shocks – like the 2008/2009 financial crisis – the vulnerability to a pandemic shock depends also, and above all, on how regions are positioned with respect to the emergence and diffusion of the disease. Given that diseases typically emerge in a local way (like COVID-19 that started in Wuhan, China), and then spread through physical contacts with a time delay (like what happened in Italian regions and in other European ones during the burst of COVID-19), the analysis of the local risk of health crises requires us to take seriously into account the patterns of individual mobility that characterize and differentiate places, in terms of people that move within and across them. Although the literature on the geographical diffusion of diseases is sizeable (Charu et al., 2017; Kuchler et al., 2020; Franch-Pardo et al., 2020), the spatial spread of COVID-19 using granular mobility data is much less investigated. Therefore, the analysis of mobility turns out to be crucial also when it comes to understand the "resistance" of regional systems (Martin et al., 2016). Especially soon after its inception, the depth of the effect of a pandemic shock depends on "lockdown" measures, through which national and local governments impose travelling and moving restrictions, which insist on heterogeneous mobility patterns within and across regions. While reducing the risk of contagion, these mobility containment policies do also slow down the economic activities and the economic recovery of the region, making it less capable of renewing its development trajectories (Massaro et al., 2018).

In the case of a health crisis like COVID-19, mobility affects a type of "resistance" that should be preliminary to economic resistance, i.e. "human" resistance, which economic studies have become familiar with and started investigating in terms of excess mortality (e.g. Cerqua et al., 2020).[1] Such a mortality in fact directly depresses and opposes the regeneration of workforce and human capital on which the resistance, reorientation and recoverability of a region crucially depends. On this basis, the extent to which regional patterns of mobility affect regional mortality in the aftermath of COVID-19, represents an extremely relevant element in the analysis of the local capacity to react to shocks. On this relationship we will focus in our empirical application, but by making an important choice about the unit of analysis through which we investigate the phenomenon.

2.1. Mobility and the case for functional spatial units

The attention that is necessary to pose on mobility in the response to COVID-19 (and other possible future pandemics) imposes a reflection about the appropriate spatial level of analysis. As it is well-known, regional borders are – in both their administrative (e.g. NUTS2 or NUTS3) and functional (like in the case of regional production/innovation systems) specification – an important factor of discontinuity for the occurrence and effects of individual mobility. Along with other factors, within-region individual mobility contributes to constitute local economic bases that are heterogeneous across them (for example, in terms of specialization in geo-

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[1] Pandemic crises are first, and above all, health and humanitarian crises. Economic problems emerge in consequence of that and manifests in ways that are related to its own nature (see Gong et al., 2020). First, local economic activities shrink because of workforce absenteeism. Second, their depression is inevitably caused by lockdown policies, which decrease or even stop the demand in mobility-related industries, like tourism, restoration, and retailing. Third, local manufacturing industries that depend on imports are affected by the disruptions of global value chains. Fourth, the availability of resources for economic activities is affected by the shift of state and regional budgets to the health sector. Because of these problems, investments and production inevitably fall, and the same happens to the demand for goods and services. Asset prices are negatively affected by this situation and entails a worsening of financial conditions, which in turn make investments fall again.

graphically concentrated economic activities); and that have been proved to be a significant vehicle of disease transmission and a determinant of its related mortality (Ascani et al., 2020). Along this line, we are assisting to a proliferation of studies that relate the effects of COVID-19 to the characteristics of regional economies (Boise and Tancioni, 2021, among others).

However, regions might not be the most salient units of analysis to address the effects of mobility on the COVID-19 mortality at the local level. First, regions host and confound sub-regional patterns of mobility that are heterogeneous and arguably have heterogenous effects on the spread and mortality of a virus. Second, regions are heterogeneous along such a wide set of dimensions to prevent us from ascertaining with accuracy the extent to which COVID-19 mortality is actually traceable to mobility. More reliable insights on the relationship at stake could be drawn by referring to another local unit of analysis, that of "spatial labour markets", meant as local (sub-) labour markets that are precisely defined in terms of "patterns of mobility between places and occupations" (Martin, 2000). The idea of travel-to-work area - defined in terms of daily commuting behavior - on which the companion notion of "local labour market" has been built up, actually represents a criterion that helps overcome the two previous limitations of a (larger) regional focus. Furthermore, it identifies sub-regional areas with respect to which the COVID-19 mortality effect of mobility could be more meaningfully compared and investigated at the local level. The notion of "labour market areas (LMA)", through which that of local labour market has been operationalized for the sake of empirical measurement, clearly reveals its advantages in the analysis we are proposing: "*LMAs … are sub-regional geographical areas where the bulk of the labour force lives and works, and where establishments can find the largest amount of the labour force necessary to occupy the offered jobs*" (ISTAT, 2014, p.1).[2] First of all, LMAs are not pre-defined by regional administrative boundaries, they are sub-regional and could potentially span across different neighbouring regions.[3] Second, and more importantly, LMAs are homogeneous in their being all "self-containing" of the mobility that refers to travel-to-work and commuting behaviours. Developed through an allocation process informed by the analysis of commuting patterns, as resulting from population census, the distinguishing feature of a LMA is actually its twofold ability to: i) maximise the relationships inside its border; ii) minimise them across borders.

While this is the distinctive ability of any LMA, different LMAs inevitably have a different capacity to implement it and thus show different extent of being actually self-containing. Some LMAs could have denser internal relationships than other, and/or they could be relatively more permeable to external relationships, both inward and outward. This heterogeneity is due to a number of reasons, which span from the morphological features of the territory on which LMAs insist (e.g. different physical barriers to internal vs. external mobility), to the kind of industry/industries to which LMAs provide the necessary labour force (e.g. heterogeneous industries requiring a different extent of contacts, like manufacturing vs. services). These and other factors make LMAs reveal mobility patterns that, while self-containing in principle and thus functionally comparable, are heterogeneous and affect the spread of the virus and its mortality within them.

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[2] The definition comes from the National Statistical Office of Italy (ISTAT), but it is coherent with harmonised methodology and standardised definitions that are usable and replicable in the whole EU (https://ec.europa.eu/eurostat/cros/content/labour-market-areas_en)

[3] LMAs are not defined with respect to administrative boundary constraints. In the case of Italy, on which we will refer in the empirical application, 56 of the identified MLAs (9.2%) cut across regional boundaries and 185 (30.3%) span across different provinces (NUTS3). In some cases, like Voghera and Melfi, LMA even cut across three regions (NUTS2).

2.2. COVID-19 mortality and mobility within and across LMAs

To start with, we expect that the mortality induced by COVID-19 is higher in those LMAs where internal mobility is higher. With respect to the labour domain, this internal mobility, over relatively short-distances, is arguably fed by individuals who share and intersect along the same routes to work and that end up having close and frequent direct contacts. These direct contacts could, in turn, increase exponentially following their social relationships (e.g. among relatives and friends). On this basis, a higher internal mobility arguably increases the COVID-19 mortality of LMAs by increasing the rate/speed of diffusion of the virus within them.

We also expect that LMAs with a higher external mobility could experience more COVID-19 mortality. This could be due to the fact that – still by focusing on the labour domain –workers who escape the LMA logic, and are incapable or unwilling to find a job within it, follow longer (than commuting-based) and less crowded routes to work and, while possibly reducing the mass of contacts, can act as vehicles of transmission across LMAs. This could be the case of both inward mobility, with infected incomers from other LMAs that bring the virus in a healthy focal one; and outward mobility, with healthy outcomers from an LMA who catch the virus and bring it back to their origin LMA. One way or the other, a higher external mobility arguably increases the COVID-19 mortality of LMAs by increasing the chance of the inception of the virus within them. Of course, as internal and external mobility normally occur simultaneously, a further interesting question is whether the mortality impact of the former is identical, larger or smaller than the latter. On the one hand, it could be claimed that internal mobility entails closer and thus more trustable contacts, with respect to which individuals of the focal LMA could take less safeguards than with respect to unfamiliar (and thus more suspected of illness) contacts from outside of it. On the other hand, it might be the case that, through external mobility, the LMA opens up to locally unfamiliar infective situations or even virus variants, which could end up more disruptive than those alimented by internal mobility. As both the effects, along with possibly other contrasting ones, could be equally plausible, we do not have a-priori expectations on this comparative effect. Accordingly, we leave the test of the comparative mortality impact of COVID-19 between inward and outward mobility of LMA to our empirical application.

2.3. COVID-19, mobility and local economic heterogeneity

As we have previously argued, investigating whether the internal/external mobility of LMAs significantly affect the mortality impact of a disease (like the COVID-19) within them, is of fundamental importance to evaluate the functioning of spatial labour markets in the face of the pandemic. Further insights on this issue can be obtained by disentangling how the same mobility patterns affect the COVID-19 mortality of LMAs with different features. In particular, LMAs that, while sharing their defining criteria (of autonomy, homogeneity, coherence and conformity, on which see ISTAT, 2014), 'serve' economic activities of different nature. A first important element of distinction to retain is the diversity between LMAs and industrial districts (IDs), which in Italy and in other countries are empirically detected and mapped by starting from the recognition of LMAs and by searching for additional qualifying features of them represented by their hosting a dominant presence of SMEs and a manufacturing specialization based on SMEs (see Lombardi, 2016).

Following the Marshallian idea, IDs are local systems of production where the presence of labour pooling, which the notion of LMA operationalises, is accompanied by a large presence of co-localised SMEs, specialized in specific production sub-phases of the same production process. In other words, and in brief, while LMAs

are just potential "basins of workers", IDs are explicitly industrial agglomerations. This fact, which distinguishes IDs from LMAs, adds to the commuting-based mechanism typical of the latter, further agglomerative mechanisms that can be expected to make the relationship we are investigating with the spread of Covid19 more evident with respect to the former. Accordingly, we expect that the spread of COVID-19 through worker mobility and their mortality impact would be larger in IDs than in LMAs that do not qualify as such. Of course, IDs as well as LMAs are inherently heterogeneous with respects to other aspects that could affect the spread of the virus. For example, the presence of leading firms or of stronger industrial associations within them could somehow accentuate the relationship at stake, while the widespread and "more democratic" atmosphere of the IDs could be expected to play an opposite role. Unfortunately, these points cannot be tested with the data at our disposal, but for sure deserve attention in future research.

An additional feature that could moderate the COVID-19 mortality impact of mobility within LMAs is of course the nature of the economic activities to which they provide labour inputs. As recent studies have shown (Ascani et al., 2020), the kind of sectors that constitute the economic base of regions has significantly affected the mortality impact of COVID-19. This is the case, for example, of manufacturing vs. service activities, which are arguably marked by different extents and patterns of mobility. Given the explicit focus of this study on mobility and LMAs in times of COVID-19, we find more salient to look at the economic activities that the government identified as "essentials", that is, as deserving exemption from the containment measures designed during lock-down periods. In the case of Italy, on March 22nd 2020 the Italian government adopted a decree - Decreto del Presidente del Consiglio dei Ministri (DPCM) – that, as part of the measures to limit the diffusion of COVID-19, froze all economic activities not considered as essential, allowing only essential ones to operate.[4] Leaving aside the debate that has accompanied the identification of these essential activities, in particular with respect to the kind of jobs connected to them,[5] what is relevant, for the sake of our argument, is their mobility impact. Indeed, it can be claimed that the local areas in which the presence of essential activities was higher, inevitably had higher worker mobility. Accordingly, this is another issue to which we will turn our empirical application in the next Section.

3. Data and empirical modelling

To study the relationship between LMAs and COVID-19 mortality, we employ data from several sources. Our outcome variable is an estimate of mortality rate at LMA-day level. These data have been originally employed by Cerqua et al. (2020), who obtained the estimates using machine learning (ML) algorithms. ML allowed an increase in the predictive power of the counterfactual mortality scenario, in absence of the pandemic, of about 18%.[6] The gain obtained in predictive power was particularly higher for smaller cities and this is important in the case of Italy, which is characterized by a myriad of very small municipalities. Fig. 1 shows the deciles of excess mortality in the Italian LMAs during the period February 23 – April 21. The Northern regions, Lombardy and Piedmont in particular, have been much more severely hit by the pandemic than Southern regions. In some Northern LMAs, corresponding to the

highly concentrated industrial provinces of Bergamo and Brescia, the excess mortality rates have been dramatic, overtaking 15,000%. In the South, the highest mortality rates have been experienced in LMAs belonging to the region Campania, an area characterized by very high population density. To capture information on individual mobility, we collected data from Facebook (FB) Disease Prevention Maps (FBDPM, hereafter), which are part of the Facebook's Data for Good Program.[7] From the FB data, we use the "Movement across tiles" (MAT) dataset and the "Facebook population" (FBPOP) dataset.

The MAT dataset provides granular mobility information for the whole of Italy on the number of individuals using FB every eight hours since February 23rd. Mobility measures are expressed as differences with respect to the average number of movements during the three weeks before the lockdown occurred in March 11th. We merge MAT data with the Italian LMAs dataset provided by ISTAT[8]. Due to the FB data limitations, we restrict our analysis up to April 21st. Mobility is expressed as the number of people moving between tile pairs over a given time period. Each tile contains two couples of geographical coordinates, respectively for starting and ending locations, the number of individuals who move across the tile, precise time and distance traveled (in km). From these data, which correspond to a total of about 2.5 million observations, we drop "zero-distance" travels and assign each tile's coordinates using a simple spatial join with an administrative city boundary (corresponding to the Eurostat Local Administrative Unit – LAU – classification) and collapse the data at municipality-day cells.

This intermediate step is necessary in order to calculate mobility flows across cities and within each LMA, since each cell contains the number of individuals who use FB and move across municipalities. We thus further collapse the data by summing the number of movements in each day both across cities within each LMA, and across cities of different LMAs, for a total of 23,500 LMA × day cells. We then calculate density measures dividing the number of movements by the number of FB users in each cell using information from the FBPOP dataset, obtaining three final mobility measures: in-flow density and outflow density to capture mobility across LMAs, and intra-flow density to capture mobility within each LMA[9]. Figs. 2 and 3 show, respectively, the geographical pattern of in-flow and intra-flow mobility, before and after the first national lockdown occurred since March 11th.

Both in-flow and intra-flow mobility dropped significantly, with no LMAs remaining in the highest density class after the lockdown. Surprisingly, the mobility drop appears also in the most populated and connected areas, such as in the Capital city of Rome and around the city of Milan, which constitute the most important LMAs in Italy. Interestingly, Fig. 3 shows that intra-flow mobility decreased much more than in-flow mobility; this figure warrants our research hypotheses discussed in Section 2 if we consider that LMAs are supposed to serve as self-containing areas and that dur-

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[4] Similar measures have been taken in other countries, also outside of Europe, and in less developed areas. For the case of Mexico, for example, see https://macf.com.mx/wp-content/uploads/2020/08/ClienAlert_Laboral0508_ing.pdf

[5] With respect to Italy, see for example Caselli et al., 2020, Boeri et al. (2020) and INPS (2020).

[6] The excess mortality estimates represent a more reliable outcome to measure the mortality that was likely due to the COVID-19 with respect to what would have happened in absence of the pandemic. The authors are grateful to Augusto Cerqua for providing the mortality data.

[7] According to Facebook, FBDPM data are designed to help public health organizations close gaps in understanding on where people live, how people are moving, and what their internet connectivity is to improve the effectiveness of health campaigns. These datasets, when combined with disease burden and epidemiological information from health systems, assist health teams in reaching vulnerable communities more effectively with health commodities and messages, and help researchers to better model the pathways of disease outbreaks that are spread by human-to-human contact. For further information see: https://www.facebook.com/help/geoinsights

[8] See https://www.istat.it/it/archivio/252261.

[9] By normalising our mobility measures by Facebook population, we mitigate the potential bias due to the selection of individuals into using Facebook as a social media. However, recent trends suggest that this bias might affect mostly young people (aged 18-29) who represent a minor share of the total labour force (https://www.fastcompany.com/90232793/the-people-who-get-how-facebook-works-are-also-the-most-likely-to-leave-it).
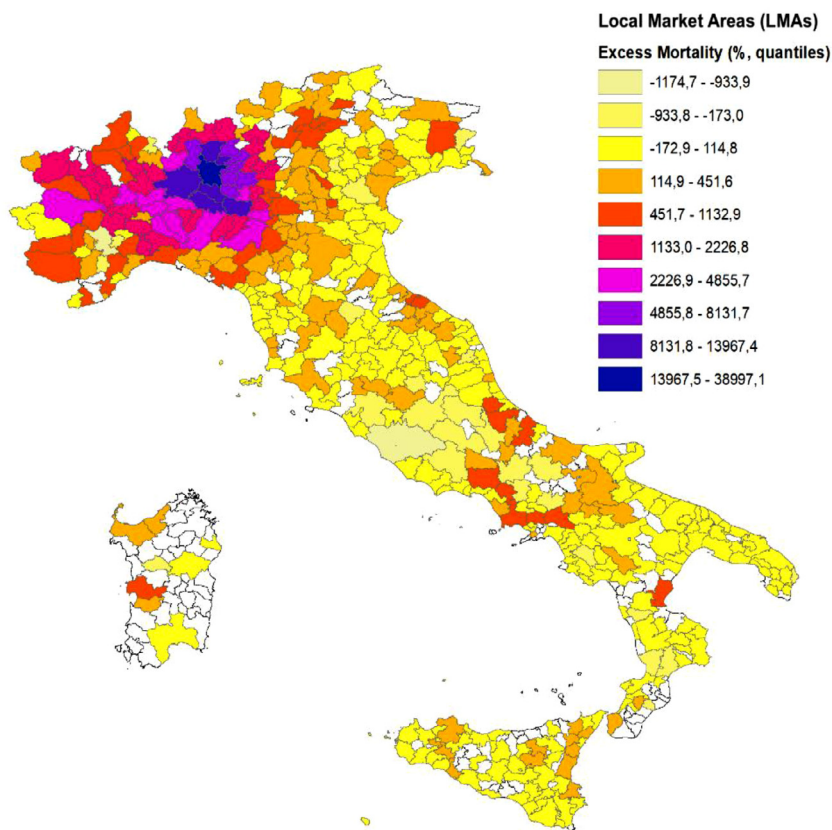
Local Market Areas (LMAs)

Excess Mortality (%, quantiles)

	-1174,7 - -933,9
	-933,8 - -173,0
	-172,9 - 114,8
	114,9 - 451,6
	451,7 - 1132,9
	1133,0 - 2226,8
	2226,9 - 4855,7
	4855,8 - 8131,7
	8131,8 - 13967,4
	13967,5 - 38997,1

Fig. 1. Excess mortality in Italy by LMA.

ing the lockdown workers were always allowed to cross regional borders to reach their workplace.

Moreover, we test the distinct role of industrial specialization and industry concentration by aligning our mobility dataset with the map of the Italian Industrial Districts (IDs) developed by IS-TAT[10] and calculate a dummy equal to one if a LMAs includes one or more IDs.

Finally, we test whether LMAs containing a larger share of workers employed in "essential sectors" – which were allowed to operate continuously during the lockdown – were associated with higher excess mortality. To identify essential sectors we exploited firm-level information on the number of employees from the OR-BIS database restricting to firms with a minimum of 4 employees in the last 3 years. We then collapse the dataset at sectoral level following the ATECO classification of economic activities developed by ISTAT and create shares of employees by sector. The essential sectors were chosen by looking at the prime minister decrees adopted in March 11/2020 and subsequently in March 22/2020[11]. The geographical distribution of essential sectors in Italy, as proxied by the number of workers employed in each economic sector, is shown in Fig. 4. We observe some clusters of LMAs with a higher concentration of essential sectors, which do not always overlap with the most urbanized areas. By and large, a larger presence of essential workers exists in the Central and Southern LMAs, mainly characterized by agricultural and food production, and a relatively higher presence of public employment. After merging this dataset with the FB data at LMA level, we create a dummy equal to one if a LMA contains a share of essential sectors above the national me-

dian. Table 1 report descriptive statistics for all the relevant variables described above.

Our goal is to test the role of mobility within and across Italian LMAs in relation to the COVID-19 pandemic. Since LMAs are assumed to have a prominent role in containing the labour mobility, thus reducing the virus spread and associated mortality, we first test if individual mobility across *vis-à-vis* within LMAs is significantly associated with a change in the excess mortality rate. To test this hypothesis, we estimate the following fixed-effect model (Eq. (1)):

$$y_{lt} = \alpha + \beta_1 Inflow_{t-\tau} + \beta_2 Intraflow_{t-\tau} + T_w + L_l + c_l T_w + \varepsilon_{lt} \tag{1}$$

where y_{lt} indicates the average excess mortality rate in the LMA l and calendar day t with lag τ. Following the medical evidence for the case of COVID-19 in Italy, we choose $\tau = 11$ days to account for the period during which the virus leads to death (Istituto Superiore di Sanità, 2020). *Inflow* and *Intraflow* are our variables of interest and represent the densities of in-flow and intra-flow FB mobilities, respectively. Moreover, T_w are calendar week fixed effects to accurately control for national policy changes and other unobserved common shocks, while L_l are LMA fixed effects to capture time-invariant labour-market specific unobserved characteristics such as size and specialization. Finally, we augment the model with LMA × week fixed effects represented by the term $c_l T_w$. This allows us to capture possible structural changes occurred at subnational level, such as conversion of production processes in specific industries/LMAs, and local changes in the containment measures (Breidenbach, 2020).

In addition to the baseline model, we test the role of LMAs with a larger presence of essential sectors in which the mobility is sup-

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[10] See https://www.istat.it/it/archivio/172446.

[11] The complete list of ATECO essential sectors is provided in Appendix Table A1.
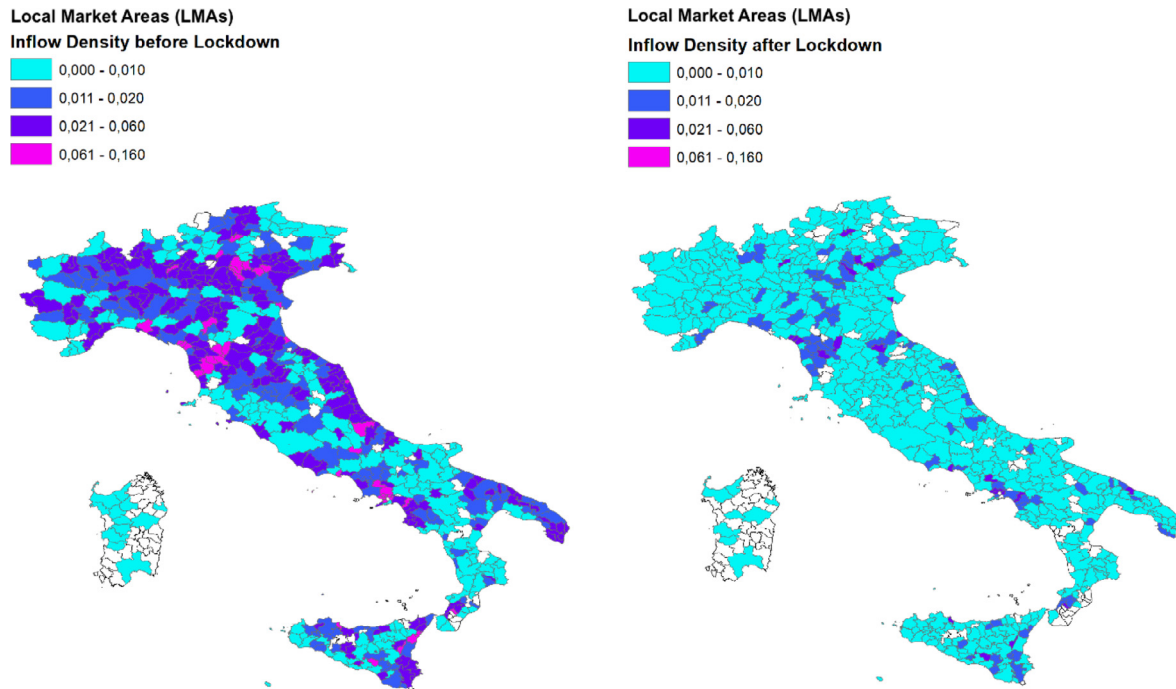
Fig. 2. In-flow mobility before and after the lockdown.
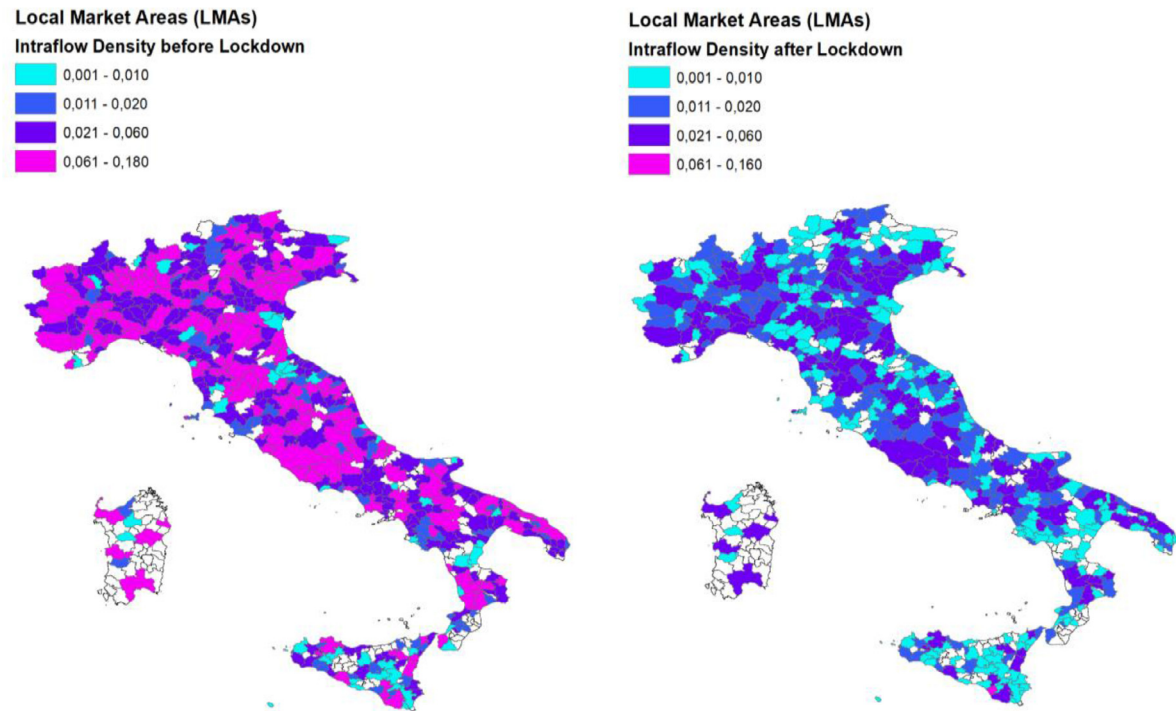
Fig. 3. Intra-flow mobility before and after the lockdown.

Table 1
Summary statistics.

Variable	Mean	s.d.	Min	Max
Excess Mortality (%)	480,409	2311,851	−3281,268	45317,766
In-flow mobility density	0,011	0,017	0	0,188
Intra-flow mobility density	0,022	0,027	0	0,234
Out-flow mobility density	0,011	0,016	0	0,187
LMAs with district (dummy)	0,286	0,452	0	1
LMAs with prevalence of essential sectors (dummy)	0,485	0,500	0	1

Number of observations is 20,328.

LMAs by share of workers in essential sectors

- 0,05 - 0,36
- 0,37 - 0,45
- 0,46 - 0,52
- 0,53 - 0,58
- 0,59 - 1,00
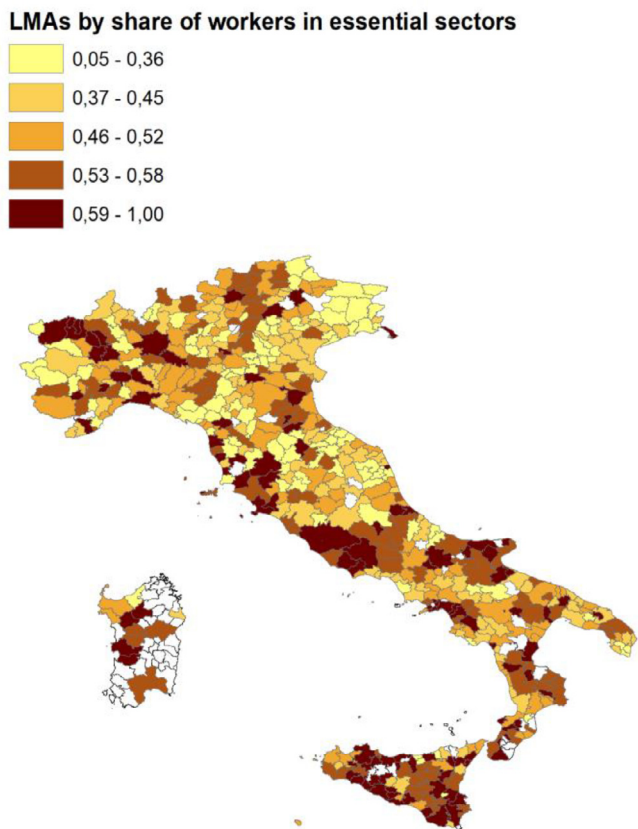
Fig. 4. Map of LMAs by share of workers in essential economic sectors.

posed to be higher, and the role of IDs. The analysis is carried out by splitting the full sample in two sub-samples with LMAs characterized by a higher and lower presence of essential sectors and IDs, respectively.

4. Results

4.1. Baseline results

Table 2 reports the results for the estimation of Eq. (1), where we focus on the relationship between local excess mortality and the mobility of individuals within and across Italian LMAs during the first wave of the COVID-19 pandemic. We estimate three different specifications by gradually adding different sets of fixed effects to the empirical model. In column 1, we only account for fixed effects at the LMA level, thus controlling for time invariant spatial heterogeneity affecting local mortality. In column 2, we add

Table 2
Estimates of the effect on In-flow and Intra-flow mobility on the excess mortality.

Dep. Variable	Excess mortality (%)		
	(1)	(2)	(3)
In-flow density	-810.96	2,176.38	664.10**
	(2,209.84)	(2,061.10)	(321.05)
Intra-flow density	-8,563.88***	-5,797.51**	863.88***
	(2,482.92)	(2,798.57)	(264.79)
Obs.	14,972	14,972	14,869
LMA FE	x	x	x
Week FE		x	x
SLL × Week FE			x

Standard errors, in parentheses, are clustered on LMAs. *** p<0.01, ** p<0.05, * p<0.1.

weekly fixed effects in order to capture potential time effects in the spread of the infection. Finally, in column 3 we enter an interaction term between LMA and week fixed effects with the idea that LMA-specific trends can be a very relevant source of unobserved heterogeneity in explaining the patterns of excess mortality, as explained in the methodology Section 3. This more stringent specification delivers results in line with the general expectation that higher flows of individuals are positively correlated with excess mortality. On the contrary, the absence of LMA time trends from the empirical model produces results based on the idea that LMA specific effects on local excess mortality do not change over time. In this case, we cannot control, for instance, for the fact that different local measures to tackle the pandemic are adopted with different timings across the country or, more generally, that local unobserved conditions in the spread of the infection have changed over time. Unsurprisingly, the estimated coefficients in columns 1 and 2 exhibit counterintuitive signs, as the absence of the interaction between LMA and week effects may introduce a relevant omitted variable bias. We report these results for completeness and to suggest that controlling for the interplay between spatial and time effects is very relevant in this setting. In column 3, in fact, our estimates suggest that individuals' mobility can be a vehicle for the spread of COVID-19 across space. Consistent with the discussion of Section 2, close and frequent human interactions entailed by high mobility within a LMA can generate local infections and feed sustained mortality figures. At the same time, LMA external linkages in terms of inflows of individuals also emerge as conducive of more deceases. Specifically, a one unit increase in the inflow of individuals in a LMA at any given point in time is related to an excess mortality of 728% eleven days after, while a one unit increase in mobility within LMAs is associated with an excess mortality of 850% with the same time lag. To better gauge the magnitude of these correlations, a one standard deviation increase in the inflow of individuals in a LLM is related to a 12% increase in local mortality, whereas a one standard deviation increase in the within-LLM mobility is connected to a mortality increase of about 23%.

Hence, these results not only suggest that individuals' mobility can be a notable transmission channel of infection within each LMA unit, ultimately affecting local mortality figures, but also that mobility across LMA boundaries can spread the geographical diffusion of COVID-19 over larger areas. In this sense, LMAs do not emerge as self-containing local units in relation to infections, but they are susceptible of contagion through the inward mobility of external actors. As a consequence, people residing in one LMA and working in another can play the role of "battering rams" that break open the boundaries of LMAs and allow the infection to penetrate in different spatial units. Hence, this battering ram effect (BRE) can be a channel for the spatial propagation of the infection into new and healthy LMAs.

While mobility plays a role both within and across LMAs, comparing the numbers above suggests that the role of individuals' movements within LMAs in spreading the virus is comparatively larger than that of mobility across LMAs, intended as inflows of people in a given LMA from other areas. This may imply that the severity of COVID-19 in each LMA, in terms of local mortality, is to a larger extent connected to the behaviour of individuals moving within the local context. For instance, it is possible that internal mobility involves closer and thus more trustable contacts, with respect to which individuals could take relatively less safeguards against COVID-19 than with respect to unfamiliar environments that entail longer movements.

In Table 3 we repeat the same exercise by considering individuals' outflows from LMAs, rather than inflows. Consistent with the findings commented above, the inclusion of LMA time trends is a fundamental element to control for time differences in local con-

Table 3
Estimates of the effect on out-flow and intra-flow mobility on the excess mortality.

Dep. Variable	Excess mortality (%)		
	(1)	(2)	(3)
Out-flow density	-1,105.64	2,334.37	538.22*
	(2,003.77)	(1,960.47)	(276.01)
Intra-flow density	-8,953.34***	-6,400.05**	915.96***
	(2,491.88)	(2,681.07)	(260.24)
Obs.	14,972	14,972	14,869
LMA FE	x	x	x
Week FE		x	x
SLL × Week FE			x

Standard errors, in parentheses, are clustered on LMAs. *** p<0.01, ** p<0.05, * p<0.1.

Table 4
Estimates of the effect on in-flow and intra-flow mobility on the excess mortality during the weekends.

Dep. Variable	Excess mortality (%)		
	(1)	(2)	(3)
In-flow density	-1,638.41	-2,028.28	-2,199.54***
	(2,350.63)	(2,346.30)	(723.10)
Intra-flow density	-10,054.58***	-10,504.13**	-1,061.12*
	(2,919.12)	(4,133.37)	(616.91)
Obs.	4,206	4,206	3,746
LMA FE	x	x	x
Week FE		x	x
SLL × Week FE			x

Standard errors, in parentheses, are clustered on LMAs. *** p<0.01, ** p<0.05, * p<0.1.

ditions. Results in column 3 suggest that local excess mortality is positively associated with the local outflow of people, even if at the 10% level. Specifically, a one unit increase in the outflow of individuals from a LMA is related to an excess mortality of 538% eleven days after. This implies that mortality in a given LMA is also connected to the number of local residents that move to other LMAs. This result may be suggestive that the people spreading the virus across LMA boundaries can also get infected in the LMA of destination, first, and carry the virus back in their LMA of origin afterwards. Therefore, the dynamics related to the diffusion of COVID-19 through individuals' outward mobility, as they emerge from Table 3, suggest that a Trojan horse effect (THE) can also be at work. This implies that some individuals unwittingly become "trojan horses" rather than being "battering rams", as they may carry the infection at home rather than bringing it from home. At the same, time the role of the individuals' mobility within LMAs remain statistically significant and positive, similar to Table 2. In this case a one unit increase in the mobility of individuals within an LMA is related to an increase of mortality of 916%. In comparative terms, the role of mobility within LMAs is again relatively more pronounced than that of mobility between LMAs. This reinforces the idea that the interactions fed by movements within the boundaries of an LMA can be more conducive of infections, probably due to the higher density of contacts and the potentially lower attention to safeguard measures taken within more familiar social contexts.

Table 4 replicates the regressions of Table 2, with the difference that we only consider weekends in this new set of estimations. One concern with the previous specifications, in fact, could be that the positive effects detected above are driven by the mobility of people during the weekends, rather than weekdays. In this case, it would be less likely that the observed mobility is related to work activities as compared to generic non-work movements. Hence, Table 4 offers a placebo test aimed at clarifying the relationship between local excess mortality and people's mo-

Table 5
Estimates of the effect on In-flow and Intra-flow mobility on the excess mortality in LMAs with industrial districts.

Dep. Variable	Excess mortality (%)	
	(1) LMA with district	(2) LMA without district
In-flow density	863.201	405.491
	(734.715)	(305.283)
Intra-flow density	1,285.507*	669.046***
	(708.412)	(246.951)
Obs.	4,299	10,570
LMA FE	x	x
Week FE	x	x
SLL × Week FE	x	x

Standard errors, in parentheses, are clustered on LMAs. *** p<0.01, ** p<0.05, * p<0.1.

bility on weekends. In line with our expectations, the results do not show any positive and significant coefficient across models using weekends only, suggesting that the relationship under analysis is realistically connected to workers' mobility on weekdays rather than generic movements of people on weekends. This is also consistent with the evidence that the infection more frequently occurs through continuative and long interactions (WHO, 2020; Dingel and Neiman, 2020), which are conditions that characterize jobs and work environments more systematically than non-work related activities occurring over weekends. At the same time we detect a negative and significant relationship between local excess mortality and mobility, even when controlling for the interplay between LMA-specific fixed effects and weekly fixed effects in column 3. This surprising result may be associated with the intuitive fact that in locations with higher mortality people decide to move less during weekends in order to minimize the risks of infections or, also, it is possible that local authorities impose restrictions to mobility in areas strongly hit by COVID-19, as evidenced in the case of many countries during the pandemic (e.g. Alwan et al, 2020). This is for instance the case of many areas in Italy at the beginning of March 2020 following the DPCM named *#Io resto a casa* (#I stay home).

4.2. The role of industrial districts

As discussed in Section 2, the presence of an industrial district denotes a large set of functional and coordinated interactions, of both competitive and cooperative nature, between firms and workers within a specific geographical space (e.g. Marshall, 1919; Becattini, 1990; Belussi and Caldari, 2009). This implies that LMAs with industrial districts may exhibit denser exchanges and localized business networks than LMAs without industrial districts. As a consequence, these systematic interdependencies may exacerbate the spread of COVID-19 through individuals' mobility, as compared to LMAs where firms operate in a relatively more isolated basis. Following this line of reasoning, Table 6 presents the results for an estimation where we separately consider LMAs with and without industrial districts, in columns 1 and 3 respectively, based on information taken from the map of the Italian Industrial Districts (IDs) developed by ISTAT. In both cases, individuals' mobility within an LMA is positively and significantly related to local excess mortality, even if the statistical significance of the coefficient in column 1 is slightly lower than in column 2. Nevertheless, the magnitude of the effect is almost double in LMAs with industrial districts as compared to LMAs without, thus suggesting that the density of systemic interactions within LMAs characterized by firms operating within an industrial district can be more conducive of infections through the local movement of people. In these cases, in fact, a one unit increase in mobility within an LMA with an industrial

Table 6

Estimates of the effect on in-flow and intra-flow mobility on the excess mortality in LMAs with essential sectors.

Dep. Variable	Excess mortality (%)	
	(1) LMA with essential sectors	(2) LMA without essential sectors
In-flow density	1,111.80*	604.61*
	(609.07)	(328.05)
Intra-flow density	1,127.28**	571.88**
	(450.08)	(254.71)
Obs.	7,257	7,612
LMA FE	x	x
Week FE	x	x
SLL × Week FE	x	x

Standard errors, in parentheses, are clustered on LMAs. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

district is associated with an increase in local mortality of 1,286%, while this effect decreases to 669% in LMAs without industrial district.

4.3. Essential versus non-essential sectors

One important aspect regarding the role of individuals' mobility within and across LMA boundaries is connected to the nature of the economic activity characterizing local jobs. In fact, as previously mentioned, the Italian government adopted a DPCM on March 22nd to limit the diffusion of the COVID-19 infection by freezing all economic activities not considered as essential. On the contrary, essential sectors were allowed to operate and workers involved in these activities to reach their workplace. This implies that LMAs with larger endowments of essential sectors witnessed more constant and sustained patterns of mobility as compared to LMAs with a lesser presence of essential activities. Hence, the next empirical step of this article is to explore whether the presence of essential versus non-essential sectors at the LMA level plays a role in catalyzing the effect of mobility on local excess mortality. Using the employment-based measure discussed in Section 3, we divide our sample of LMAs based on the local relevance of essential sectors. Table 6 presents the results for the estimation of Eq. (1) for LMAs with an above and below median employment share in essential sectors. While the relationship between individuals' mobility and local excess mortality remain significant and positive across specifications, the magnitude of the effect of mobility in LMAs with a large endowment of essential sector is notably larger than in LMAs with weak presence of essential sectors. For instance, a one unit increase in the mobility within an LMA with a strong presence of essential sectors is related to an increase of mortality of 1,127% eleven days after, whereas this effect is equal to 572% in LMAs with weak specialization in essential sectors. Similarly, a one unit increase in the inflow of people in a LMAs with large endowment of essential sectors is associated with an increase of 1,112% in local mortality. However, this effect falls to 605% for inflows in LMAs with more non-essential economic activities. Taken together, these results suggest that individuals' mobility can be a vehicle of disease transmission per se, but also that blocking non-essential activities may not be sufficient to stop the spread of the virus. The very strong effects associated with the mobility of individuals in areas characterized by the large presence of essential sectors, in fact, indicates that the death toll has increased especially where economic activities and transactions were allowed.

5. Conclusions

Labour markets constitute systemic economic structures that are very sensitive to shocks and perturbations. While in recent years a number of important disturbances, such as the financial

crisis, Brexit or the new technological developments connected to automation, have affected the functioning and characteristics of labour markets, the COVID-19 pandemic and the consequent lockdown measures adopted in many countries represent an unprecedented health and economic disaster, and an unexpected stress test for the functioning of local labour markets. While regional and urban studies on COVID-19 are proliferating, large aspects of the pandemic crisis still remain scarcely investigated or understood, especially in a regional development perspective. The spatial dimension of the pandemic at the sub-national level, in fact, indicates a clear uneven pattern of infection and mortality, thus suggesting that local adaptation and resistance to this specific shock are fundamentally heterogeneous across geographical space. In this context, we offer an analysis of the interplay between spatial labour markets and COVID-19 by studying how the patterns of individuals' mobility within and across LMAs are connected to locations' excess mortality. As infections occur through human interaction, mobility represents the primary channel connecting labour markets to the spatiality of COVID-19. Hence, the unevenness of COVID-19 diffusion entails that local labour markets are characterised by dynamics and mechanisms that are far from homogeneous. We explore these ideas by using excess mortality data for Italian LMAs as well as novel information on the movement of individuals taken from the Facebook Disease Prevention Maps. The latter allows us to construct measures for individuals' movements within and across LMAs. A such, we are able to consider the diverse features of LMAs concerning their internal degree of mobility as well as their exchanges with other LMAs during the pandemic. By estimating high-frequency panel data models, we consistently find a positive relationship between intra-LMA mobility and local excess mortality – an association in line with the expectation that labour markets where more individuals are mobile during the COVID-19 outbreak are characterised by higher excess mortality figures. Furthermore, we also find evidence of a positive link between the inflow of individuals in a focal LMA and that LMA excess mortality (i.e. battering ram effect). Although less statistically significant, we also find evidence that the outflow of individuals from a focal LMA is related to that LMA excess mortality (i.e. Trojan horse effect).

The distinction between LMAs with the presence or the absence of industrial districts introduces a further element of interest. In line with the notion that industrial districts denote a thicker labour market and a denser network of business interaction at the local level, the effect of individuals' mobility on local excess mortality is notably exacerbated in these contexts as compared to the case of LMAs not endowed with industrial districts. Finally, we also find that the designation of essential and non-essential sectors by the Italian government as part of the anti-COVID-19 containment measures generates an asymmetry in the relationship under analysis. In fact, we detect the strongest relationships between excess mortality and individual mobility (both within and across LMAs) in the

case of labour markets with higher shares of employment in sectors labelled as "essential".

Taken together, our results are indicative that people mobility within and across local labour markets can be a mechanism of spatial diffusion of COVID-19 leading to excess mortality. In this sense, local labour markets do not seem to perform their self-containing role when it comes to the geographical diffusion of the virus. This evidence suggests that mobility can strongly affect local labour markets' resistance, not only as it can represent a transmission mechanism of infections, but also because further regional-specific lockdown measures that freeze economic activity are taken based on the local intensity of the infection.

Our analysis provides novel evidence from which policy makers could benefit in trying to contrast the unfortunate event of a revamping of this pandemic or the outbreak of a different one. In devising lock-down measurements and mobility constraints, the usual focus placed on the risk of contagion between different areas, via an as much typical mechanism of external job mobility, could not be enough to contrast the pandemic diffusion. Mobility within labour market areas is as much conducive of the spread of a virus and the same areas should thus not be looked like self-containing places against which to trade-off other policy interventions.

Appendix

Table A1.

Table A1
List of ATECO essential sectors based on the DPCM of March 22nd.

ATECO Code	Original description
1	Coltivazioni agricole e produzione di prodotti animali
3	Pesca e acquacoltura
5	Estrazione di carbone
6	Estrazione di petrolio greggio e di gas naturale
09.1	Attività dei servizi di supporto all'estrazione di petrolio e di gas naturale
10	Industrie alimentari
11	Industria delle bevande
13.96	Fabbricazione di altri articoli tessili tecnici ed industriali
13.95	Fabbricazione di tessuti non tessuti e di articoli in tali materie (esclusi gli articoli di abbigliamento)
14.12	Confezioni di camici, divise e altri indumenti da lavoro
16.24	Fabbricazione di imballaggi in legno
17	Fabbricazione di carta (ad esclusione dei codici: 17.23 e 17.24)
18	Stampa e riproduzione di supporti registrati
19	Fabbricazione di coke e prodotti derivanti dalla raffinazione del petrolio
20	Fabbricazione di prodotti chimici (ad esclusione dei codici: 20.12 - 20.51 - 20.51 - 20.59 - 20.59)
21	Fabbricazione di prodotti farmaceutici di base e di preparati farmaceutici
22.2	Fabbricazione di articoli in materie plastiche (ad esclusione dei codici: 22.29.01 e 22.29.02)
23.13	Fabbricazione di vetro cavo
23.19	Fabbricazione di vetrerie per laboratori, per uso igienico, per farmacia
25.21	Fabbricazione di radiatori e contenitori in metallo per caldaie per il riscaldamento centrale
25.92	Fabbricazione di imballaggi leggeri in metallo
26.6	Fabbricazione di apparecchi per irradiazione, apparecchiature elettromedicali ed elettroterapeutiche
27.1	Fabbricazione di motori, generatori e trasformatori elettrici e di apparecchiature per la distribuzione e il controllo dell'elettricità
27.2	Fabbricazione di batterie di pile e di accumulatori elettrici
28.29	Fabbricazione di macchine automatiche per la dosatura, la confezione e per l'imballaggio
28.95	Fabbricazione di macchine per l'industria della carta e del cartone (incluse parti e accessori)

(*continued on next page*)

Table A1 (*continued*)

ATECO Code	Original description
28.96	Fabbricazione di macchine per l'industria delle materie plastiche e della gomma (incluse parti e accessori)
32.50	Fabbricazione di strumenti e forniture mediche e dentistiche
32.99	Fabbricazione di attrezzature ed articoli di vestiario protettivi di sicurezza
32.99	Fabbricazione di casse funebri
33	Riparazione e manutenzione installazione di macchine e apparecchiature (ad esclusione dei seguenti codici: 33.11, 33.11, 33.11, 33.11, 33.11, 33.11, 33.11, 33.12, 33.16, 33.17)
35	Fornitura di energia elettrica, gas, vapore e aria condizionata
36	Raccolta, trattamento e fornitura di acqua
37	Gestione delle reti fognarie
38	Attività di raccolta, trattamento e smaltimento dei rifiuti; recupero dei materiali
39	Attività di risanamento e altri servizi di gestione dei rifiuti
42	Ingegneria civile (ad esclusione dei seguenti codici: 42.91, 42.99 e 42.99)
43.2	Installazione di impianti elettrici, idraulici e altri lavori di costruzioni e installazioni
45.2	Manutenzione e riparazione di autoveicoli
45.3	Commercio di parti e accessori di autoveicoli
45.4	Per la sola attività di manutenzione e riparazione di motocicli e commercio di relative parti e accessori
46.2	Commercio all'ingrosso di materie prime agricole e animali vivi
46.3	Commercio all'ingrosso di prodotti alimentari, bevande e prodotti del tabacco
46.46	Commercio all'ingrosso di prodotti farmaceutici
46.49	Commercio all'ingrosso di libri riviste e giornali
46.61	Commercio all'ingrosso di macchinari, attrezzature, macchine, accessori, forniture agricole e utensili agricoli, inclusi i trattori
46.69	Commercio all'ingrosso di strumenti e attrezzature ad uso scientifico
46.69	Commercio all'ingrosso di articoli antincendio e infortunistici
46.71	Commercio all'ingrosso di prodotti petroliferi e lubrificanti per autotrazione, di combustibili per riscaldamento
49	Trasporto terrestre e trasporto mediante condotte
50	Trasporto marittimo e per vie d'acqua
51	Trasporto aereo
52	Magazzinaggio e attività di supporto ai trasporti
53	Servizi postali e attività di corriere
55.1	Alberghi e strutture simili
j (DA 58 A 63)	Servizi di informazione e comunicazione
K (da 64 a 66)	Attività finanziarie e assicurative
69	Attività legali e contabili
70	Attività di direzione aziendali e di consulenza gestionale
71	Attività degli studi di architettura e d'ingegneria; collaudi ed analisi tecniche
72	Ricerca scientifica e sviluppo
74	Attività professionali, scientifiche e tecniche
75	Servizi veterinari
78.2	Attività delle agenzie di lavoro temporaneo (interinale)1
80.1	Servizi di vigilanza privata
80.2	Servizi connessi ai sistemi di vigilanza
81.2	Attività di pulizia e disinfestazione
82.20	Attività dei call center
82.92	Attività di imballaggio e confezionamento conto terzi
82.99	Agenzie di distribuzione di libri, giornali e riviste
82.99	Altri servizi di sostegno alle imprese3
84	Amministrazione pubblica e difesa; assicurazione sociale obbligatoria
85	Istruzione
86	Assistenza sanitaria
87	Servizi di assistenza sociale residenziale
88	Assistenza sociale non residenziale
94	Attività di organizzazioni economiche, di datori di lavoro e professionali
95.11	Riparazione e manutenzione di computer e periferiche
95.12	Riparazione e manutenzione di telefoni fissi, cordless e cellulari
95.12	Riparazione e manutenzione di altre apparecchiature per le comunicazioni
95.22	Riparazione di elettrodomestici e di articoli per la casa
97	Attività di famiglie e convivenze come datori di lavoro per personale domestico

CRediT authorship contribution statement

Andrea Ascani: Data curation, Methodology, Formal analysis.
Alessandra Faggian: Methodology, Writing – review & editing.
Sandro Montresor: Conceptualization, Writing – original draft.
Alessandro Palma: Data curation, Methodology, Validation.

References

Alwan, N., Burgess, R.A., Ashworth, S., Beale, R., Bhadelia, N., Bogaert, D., et al., 2020. Scientific consensus on the COVID-19 pandemic: we need to act now. Lancet North Am. Ed. 396 (10260), E71–E72.

Ascani, A., Faggian, A., Montresor, S., 2020. The geography of Covid-19 and the structure of local economies: the case of Italy. J. Region. Sci. doi:10.1111/jors.12510.

Bailey, D., Clark, J., Colombelli, A., Corradini, C., De Propris, L., Derudder, B., Fratesi, U., Fritsch, M., Harrison, J., Hatfield, M., Kemeny, T., Kogler, D., Lagendijk, A., Lawton, P., Ortega-Argilés, R., Iglesias Otero, C., Usai, S., 2020. Regions in a time of pandemic. Region. Stud. 54 (9), 1163–1174.

Becattini, G., 1990. Alfred Marshall e la Vecchia Scuola Economica di Cambridge. In: Becattini, G. (Ed.), Il Pensiero Economico: temi, problemi e scuole. UTET, Turin, pp. 275–310.

Beutels, P., Jia, N., Zhou, Q.Y., Smith, R., Cao, W.C., De Vlas, S.J., 2009. The economic impact of SARS in Beijing, China. Trop. Med. Int. Health 14, 85–91.

Breidenbach, P., 2020. Ready for take-off? The economic effects of regional airport expansions in Germany. Region. Stud. 54 (8), 1084–1097.

Boeri, Tito, Paccagnella, Marco, Caiumi, Alessandro, 2020. Mitigating the work-safety trade-off.. CEPR Covid Economics 2, 60–66.

Boise, F., Tancioni, M., 2021. Predicting the spread of COVID-19 in Italy using machine learning: do socio-economic factors matters? Struct. Change Econ. Dyn. 56, 310–329.

Caselli, M., Fracasso, A., Traverso, S., 2020. Robots and mitigation of the risk of Covid-19 contagion in the workplace: some evidence from Italy.. EconPol Opinion 34. https://www.econpol.eu/opinion_34.

Cerqua, A., Di Stefano, R., Letta, M., Miccoli, S., 2020. Local mortality estimates during the COVID-19 pandemic in Italy.. GSSI Discussion Paper Series in Regional Science & Economic Geography, 6 ISSN 2724-3680.

Charu, V., Zeger, S., Gog, J., Bjørnstad, O.N., Kissler, S., Simonsen, L., … Viboud, C., 2017. Human mobility and the spatial transmission of influenza in the United States. PLoS Comput. Biol. 13 (2), e1005382.

Davies, S., 2011. Regional resilience in the 2008–2010 downturn: comparative evidence from European countries. Camb. J. Regions Econ. Soc. 4, 369–382.

Dingel, J., Neiman, B., 2020. How Many Jobs can be Done at Home? *NBER Working Paper* No.26948.

Franch-Pardo, I., Napoletano, B.M., Rosete-Verges, F., Billa, L., 2020. Spatial analysis and GIS in the study of COVID-19. A review. Sci. Total Environ. 739, 140033.

Gong, H., Hassink, R., Tan, J., Huang, D., 2020. Regional resilience in times of a pandemic crisis: the case of COVID-19 in China. Tijdschrift voor economische en sociale geografie 111 (3), 497–512.

INPS (2020). Settori essenziali vs settori bloccati per la crisi pandemica: un'analisi dei rapporti di lavoro Uniemens. https://www.inps.it/NuovoportaleINPS/default.aspx?itemdir=53804&lang=IT

ISTAT, 2014, Labour market areas year 2011.

Istituto Superiore di SanitàISS, 2020. Caratteristiche dei pazienti deceduti positivi all'infezione da SARS-CoV-2 in Italia. Dati all'11 giugno 2020.. Report of Gruppo di Sorveglianza COVID-19. Istituto Superiore di Sanità.

Joo, H., Maskery, B.A., Berro, A.D., Rotz, L.D., Lee, Y.K., Brown, C.M., 2019. Economic impact of the 2015 MERS outbreak on the Republic of Korea's tourism-related industries. Health Secur. 17, 100–108.

Kim, K., Yoon, H.Y., Jung, K., 2017. Resilience in risk communication networks: following the 2015 MERS response in South Korea. J. Contin. Crisis Manage. 25, 148–159.

Lombardi, S. (2016). The definition of industrial districts. Paper prepared for the workshop on "Developing European Labour Market Areas" and training on TTWA method".

Kuchler, T., Russel, D., Stroebel, J., 2020. The Geographic Spread of COVID-19 Correlates with the Structure of Social Networks as Measured by Facebook. National Bureau of Economic Research (No. w26990).

Marshall, A., 1919. Industry and Trade. Macmillan, London.

Martin, R., 2000. Local Labour Markets: their nature, performance and regulation. In: Handbook of Economic Geography. Oxford University Press, Oxford, pp. 455–476.

Martin, R., Sunley, P., Gardiner, B., Tyler, P., 2016. How regions react to recessions: resilience and the role of economic structure. Region. Stud. 50, 561–585.

Martin, R.L., 2018. Shocking aspects of regional development: towards an economic geography of resilience. In: Clark, G., Gertler, M., Feldman, M.P., Wójcik, D. (Eds.), The New Oxford Handbook of Economic Geography. Oxford University Press, Oxford, pp. 839–864.

Massaro, E., Ganin, A., Perra, N., Linkov, I., Vespignani, A., 2018. Resilience management during large-scale epidemic outbreaks. Sci. Rep. 8, 1–9.

OECD, 2020. Job Creation and Local Economic Development. Rebuilding Better. OECD Press, Paris, France.

Pike, A., Dawley, S., Tomaney, J., 2010. Resilience, adaptation and adaptability. Camb. J. Regions Econ. Soc. 3 (1), 59–70.

Sensier, M., Bristow, G., Healy, A., 2016. Measuring regional economic resilience across Europe: operationalising a complex concept. Spatial Econ. Anal. 11, 128–151.

Simmie, J., Martin, R., 2010. The economic resilience of regions: towards an evolutionary approach. Camb. J. Regions Econ. Soc. 3, 27–43.

Webber, D.J., Healy, A., Bristow, G., 2018. Regional growth paths and resilience: a European analysis. Econ. Geogr. 94, 355–375.

WHO, (2020). From the new normal to a new future: A sustainable response to COVID-19. https://www.who.int/westernpacific/news/commentaries/detail-hq/from-the-new-normal-to-a-new-future-a-sustainable-response-to-covid-19.

Zeng, B., Carter, R., De Lacy, T., 2005. Short-term perturbations and tourism effects: the case of SARS in China. Curr. Issues Tour. 8, 306–317.