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Long-term impact of job loss on individual mobility behaviour

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Extended Abstract

Economic and human behavioural statistics are critical for effective decision-making. However, current estimates are often based on traditional surveys, which require a significant amount of time to collect and do not scale well with the population size. Moreover, behavioural surveys are biased towards people who are more likely to fill them (e.g. highly educated people) and have a recall bias as people tend to forget their past behaviour over time.

In this work, we leverage a dataset of privacy-enhanced longitudinal GPS mobility traces of more than 100,000 anonymous opted-in individuals, from 3 January 2020 to 1 September 2020 in Massachusetts (US), to estimate unemployment at scale and analyse human behavioural changes after the loss of the job.

For each individual, we compute the stop locations as a sequence of GPS coordinates within a radius of 65 meters where a user stayed for at least 5 minutes. Then, we give a semantic meaning to each stop by either associating it with the *Residential*, *Work*, or *Other* place. Finally, we enrich residential and workplace locations with the Longitudinal Employer-Household Dynamics (LEHD)[1] Origin-Destination Employment Statistics (LODES), which contains survey information about the US workforce divided by industrial sectors (i.e. NAICS). These surveys provide information on how many individuals work in a NAICS, given the block group where people live and work. Thanks to this survey, we assign in probability the job sector (NAICS) in which an individual may work, for all users for which we estimated a work and home location. Moreover, since COVID-19 non-pharmaceutical interventions encouraged work from home, we also estimate whether a user is working or not, correcting for the remote workability [1] of that particular job sector.

We estimate the accuracy of our methodology through the aggregated monthly statistics of Unemployment Insurance claims[2]. Our results have an average Pearson correlation of 0.85 between the number of individuals we detect as unemployed (reweighted by the employed population) and the number of unemployment insurance claims for each industrial sector (NAICS). This result highlights that our algorithm can reliably estimate unemployment at an aggregated level.

We also measure human behavioural changes after a job loss. To do so, we compare the daily mobility of individuals identified as employed/unemployed after removing all the stop locations related to an individual's workplace. We, therefore, show results on extra-work mobility to provide a fair comparison between the groups of employed and unemployed individuals.

To capture the changes and, more in general, the complexity of individuals' exploratory behaviour, we focus on two different aspects of human mobility behaviour: (i) how people allocate time in space (locations) and (ii) how many places an individual visits and how much s/he is capable of exploring different locations. In these terms, we compute the change in the

[1] https://lehd.ces.census.gov/data/

[2] https://oui.doleta.gov/unemploy/DataDownloads.asp

radius of gyration and the entropy around the visited locations as proxies of the spatiotemporal change in individual mobility patterns. Then, we compute the individual capacity C, namely the number of recurrently visited locations in a 4-week window, and the number of locations s/he adds A and removes D from her bag-of-places, as proxies of the variety of places s/he explores [2].

While, overall, the pandemic period dramatically affected individual mobility patterns, we find that unemployed individuals systematically show a higher degree of change. In particular, as the pandemic progresses, the mobility gaps between employed and unemployed groups also increase. The reduction in mobility is mirrored in a smaller size of unemployed individual capacity, C, suggesting a contraction of the unemployed individuals' mobility.

To take into account the non-negligible impact of Non-Pharmaceutical Interventions, and more in general of the pandemic, on the general population mobility during 2020, we standardise each individual's mobility indicators with the indicator average (and standard deviation) value on a specific day of the group of employed individuals (z-score). Then to reach a more general understanding of the effects of job loss on an individual, we align the mobility indicators of all individuals, shifting time such that $t = 0$ is the time at which an individual lost her/his job. With this approach, we are able to consistently compare individuals' mobility behaviour at different times with respect to the date at which they lost their job. As displayed in Fig 1B, we find that both the radius of gyration (at a smaller level) and the entropy (at a higher level) are affected and gradually decreases over time, up to nearly -0.3 and -1 standard deviation respectively, compared to the individuals who were employed.

More importantly, as mobility is affected by job loss, also the exploratory behaviour of unemployed individuals is reduced. The contraction in individual capacity is not simply generated by a localized transitory reduction in added locations or a transitory increase in removed locations, but it is the result of a sustained reduction in both added and removed locations. At the individual level, this combination of behavioural changes highlights the dangers of a self-sustaining situation, where individuals more in need of work opportunities and social support are those least exposed to what society could offer them.

Our results also provide evidence for the long-term effects of unemployment on individuals' daily lives, which can affect people's habits and social and psychological well-being. Further work will extend this approach to multiple countries.

References

[1] Dingel, Jonathan I., and Brent Neiman. "How many jobs can be done at home?." Journal of Public Economics 189 (2020).

[2] Alessandretti, L., Sapiezynski, P., Sekara, V., Lehmann, S. & Baronchelli, A. Evidence for a conserved quantity in human mobility. *Nature Human Behaviour*. **2**, 485-491 (2018)

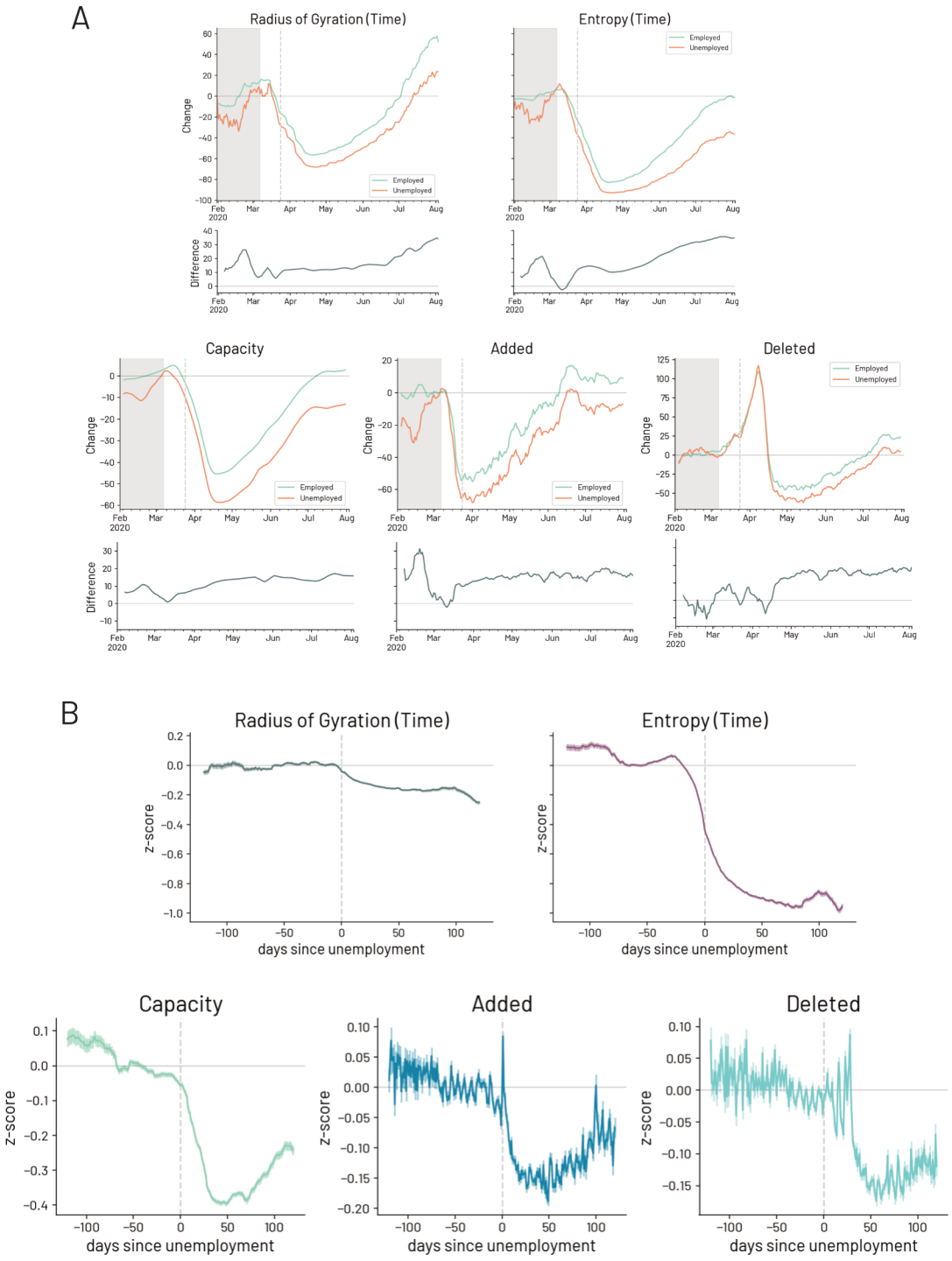

Figure 1: A) Changes in mobility metrics during the first wave of the pandemic for employed and unemployed individuals detected by our algorithm. The bottom plot for each metric shows the difference between the two groups over time. B) Effect of the job loss on an individual, after the alignment of the mobility indicators of all individuals shifting time such that $t = 0$ is the time at which all included individuals lost their job (negative numbers the individual is employed, positive numbers the individual is unemployed).