Human mobility and COVID-19 epidemic

Lucia Depaoli

N° matricola: 2016960

e-mail: lucia.depaoli.l@studenti.unipd.it

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COVID-19 epidemic

COVID-19 epidemic had an unprecedent effect on human mobility.

Governments and the scientific community needed to find a way to reduce the spreading of the disease.

Lockdowns

were established

Human

contacts

were reduced

Masks

were worn

International mobility

was not allowed

How was COVID-19 epidemic influenced by all these factors?

Were lockdowns useful for the reduction of the spreading?

Italy dataset

Datasets used for the study:

- COVID-19 Community Mobility Reports¹ (daily)
- Median of users' radius of gyration² (weekly)
- o Average degree of the proximity network² (daily)
- $\circ R_t$ computed with CovidStat algorithm³ (daily)
- Infected data⁴ (daily)

¹Google: https://www.google.com/covid19/mobility/

²Pepe, Bajardi, Gauvin, Privitera, Lake, Cattuto, Tizzoni, Scientific Data, 230 (2020): https://data.humdata.org/dataset/covid-19-mobility-italy
³ISS: https://covid19.infn.it/iss/#

⁴Dipartimento della Protezione Civile: https://github.com/pcm-dpc/COVID-19

Mobility variables

o **Percentage change from baseline** → 6 categories: Grocery & Pharmacy, Parks, Transit stations, Retail & Recreation, Residential, Workplaces.

o Average degree of proximity network $\langle k \rangle$ \rightarrow number of unique contacts made by a person on a typical day.

 Users radius of gyration → measure of the spatial range of a users' mobility patterns.

Human mobility and contacts < k >

COVID-19 spreads via human contacts: face-to-face encounters, touching of infected surfaces.

Are human contacts related to human mobility? How and how much?



Yes. A relationship between the variables is present.

Spreading variables

Number of infected people I and R_t number carry different informations:

o $I \rightarrow \text{how much}$ the epidemic is extended.

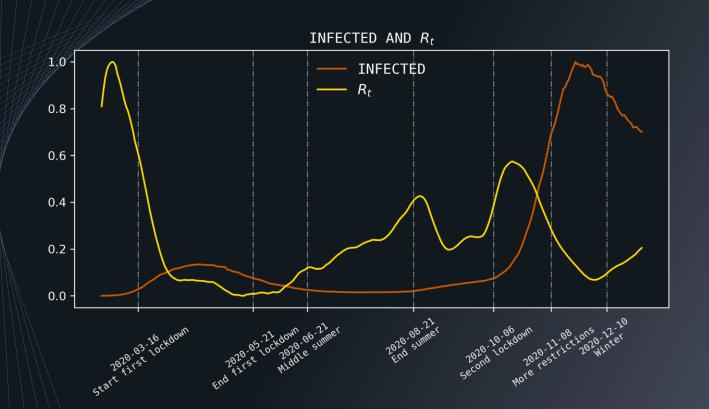
 $\circ R_t \rightarrow \text{how}$ is the epidemic spreading.

 R_t is the average number of new infections caused by a single infected at time t.

It tells us about the response of the epidemic to external factors, such as a reduction in contacts or a change in human behaviours.

The two variables are only partially related.

Spreading variables



Correlation between the variables

Does it exist a correlation between the mobility and the spreading variables?

	Retail and recreation	Grocery and pharmacy	Parks	Transit stations	Workplaces	Residential
R_t number	0.85	0.84	0.84	0.93	0.68	-0.90
Number of infected I	-0.65	-0.14	-0.62	-0.49	-0.18	0.62

 $\circ < k > \& R_t$: 0.80

∘ **Radius &** *R*_t: 0.81



Human mobility and infected number

What is the correlation between human mobility data and the infected number I?



- o **High negative correlation** for the first 5 categories of places → low mobility is related to high number of infected people.
- High positive correlation for residential category.

Human mobility and infected number

This is explanable only if there is no delay between the two variables.



 Zero-days delay → when the number of infected people was high, people mostly stayed at home. However, this result is not relevant; it is only due to the government restrictions.

Human mobility and R_t number

Let's take a look at the correlation between human mobility and R_t number.



- High positive correlation for the first 5 categories of places \rightarrow a decrease in visits outside the house leads to a reduction in R_t .
- High negative correlation for the residential category \rightarrow a decrease in time spent at house leads to a increasing of R_t .

Human mobility and R_t number

What is the shift in days that maximizes the absolute value of the correlation?

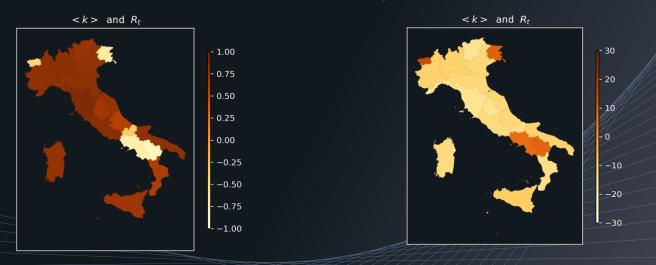


 $\sim 10\text{--}20 \text{ days} \rightarrow \text{maximum (or minimum) correlation when the <math>R_t$ is delayed.

This means that a decrease in mobility have a high impact on the decreasing of the R_t number.

Average contacts and R_t number

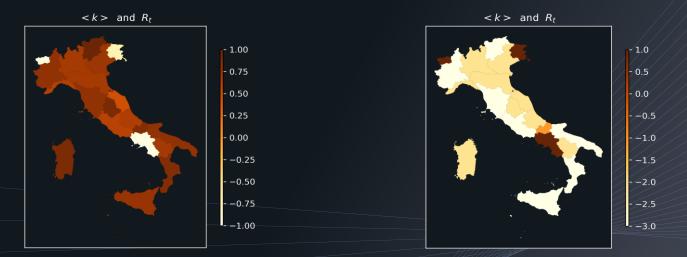
What is the correlation between $\langle k \rangle$ and the R_t number?



The results are similar to the ones obtained for the correlation between human mobility and R_t .

Radius of gyration and R_t number

What is the correlation between the radius of gyration and the R_t number?



The shift in days is of about 2-3 weeks.

Correlation for different time interval

2020 can be divided in 3 main periods:

First wave and first lockdown

until 21-05-2020

Summer

from 22-05-2020 until 21-08-2020 Second waveand secondlockdown

from 22-08-2020 until 31-12-2020

- o For mobility and $R_t \to \text{Indices of correlations consistent with the previous ones.}$ For the second half of 2020, workplace have the highest positive correlation with R_t .
- \circ For mobility and $I \rightarrow$ Indices of correlations consistent with the previous ones.

Comparison results with 2021 data

Correlation indices of 2021 are different from the one obtained in 2020. Why?

o COVID-19 tests and number of infected *I* more reliable than the year before

Less severe restictions

 Masks were mandatory in every social situation

Similar correlation but less extreme.

Conclusions

Mobility variables and R_t number are correlated.

 \circ A reduction in mobility led to a reduction in R_t number, the spreading of the disease was reduced. Lockdowns were useful

- o By monitoring the occupation of the places, we can monitor the spreading of the disease.
- o By impose specific restrictions, we can control the spreading of the disease.

Conclusions

Further studies:

- \circ Machine Learning on time series to predict R_t number from mobility.
- o Comparison with other countries.
- o Studies of the previous waves and investigate a way to prevent them.
- o Analysis on a more accurate mobility variables.

Thanks for the attention

Appendix

Human mobility and I – first 2020



Human mobility and I – second 2020



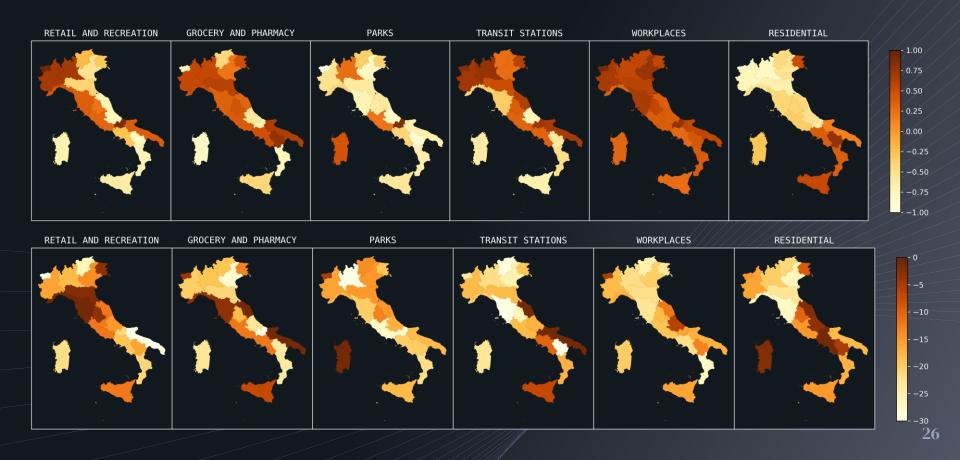
Human mobility and R_t – 02-05/2020



Human mobility and R_t – 05-09/2020



Human mobility and $R_t - 05$ -11/2020



Human mobility and $R_t - 2021$

