Unfolding and Modeling the Recovery Process after COVID Lockdowns

ZHEJIANG UNIVERSITY

Xuan Yang, Yang Yang, Chenhao Tan, Yinghe Lin, Zhengzhe Fu, Fei Wu, Yueting Zhuang

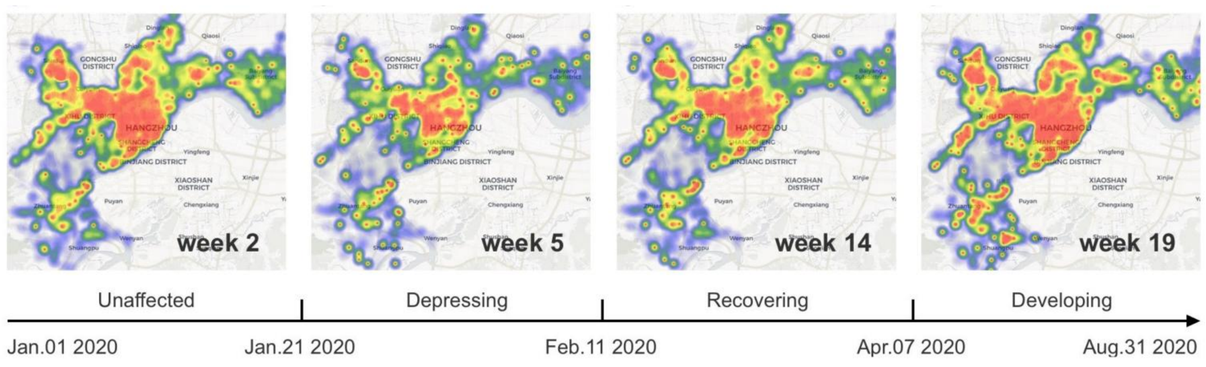
Motivation

- **Great depression.** The lockdown policies cause the closure of workplaces and educational institutions, and lead to a reduced workforce across all economic sectors.
- **Lack of recovery studies.** Few works focus on the recovery after lockdown , especially on the recovery patterns of different sectors from the depression.
- **Large-scale eletricity data.** More granular data sources rather than data (e.g. GDP) commonly used in socio-economic analysis.

Here we conduct a data-driven study on **the recovery process after COVID-19 lockdowns** based on **large-scale electricity data** in Hangzhou.

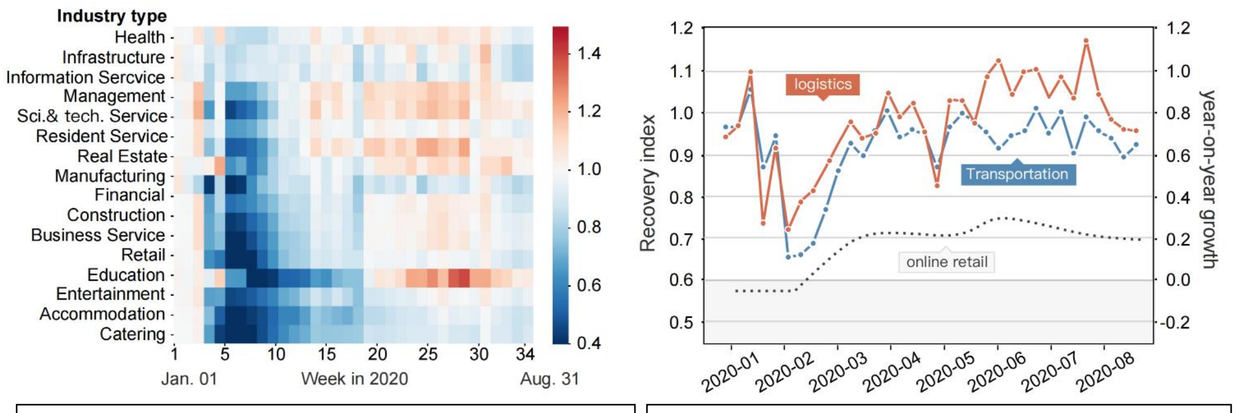
Diverse Recovery Patterns

- In order to scrutinize the depression and recovery process of a city after the lockdown policies, we utilize our daily electricity consumption data to design a recovery Index. The recovery index provides a uniform and effective measure of the recovery degree in different sectors.



The heat maps illustrate the influence of COVID-19 lockdown on the Hangzhou urban area. Each point in a heat map represents the weekly electricity consumption of an organization. Warmer colors represent greater electricity consumption.

- Based on recovery index, we observe recovery patterns of different sectors.

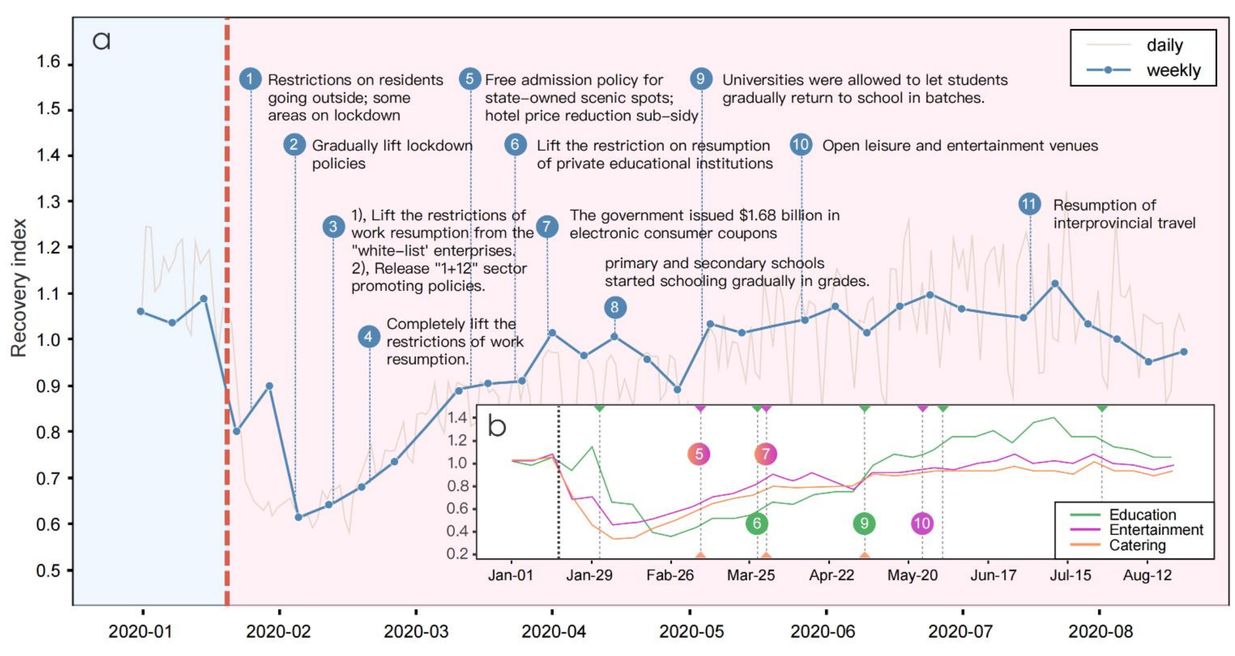


The recovery index of 17 sectors from January 1, 2020 to August 31, 2020. We ranked these sectors in the order of how quickly their recovery index reached one for the first time after week five.

By the case study on the transportation sector, we find the lockdown policies bring opportunities to logistics and online sectors.

Policy Influence on Recovery

- For the early recovery of social life and economy, the government has made efforts to enact policies of promoting recovery in various sectors. We study the effectiveness and impact of these policies by automatically detecting the change points in the evolving recovery index of each sector, and matching them with policy timings.



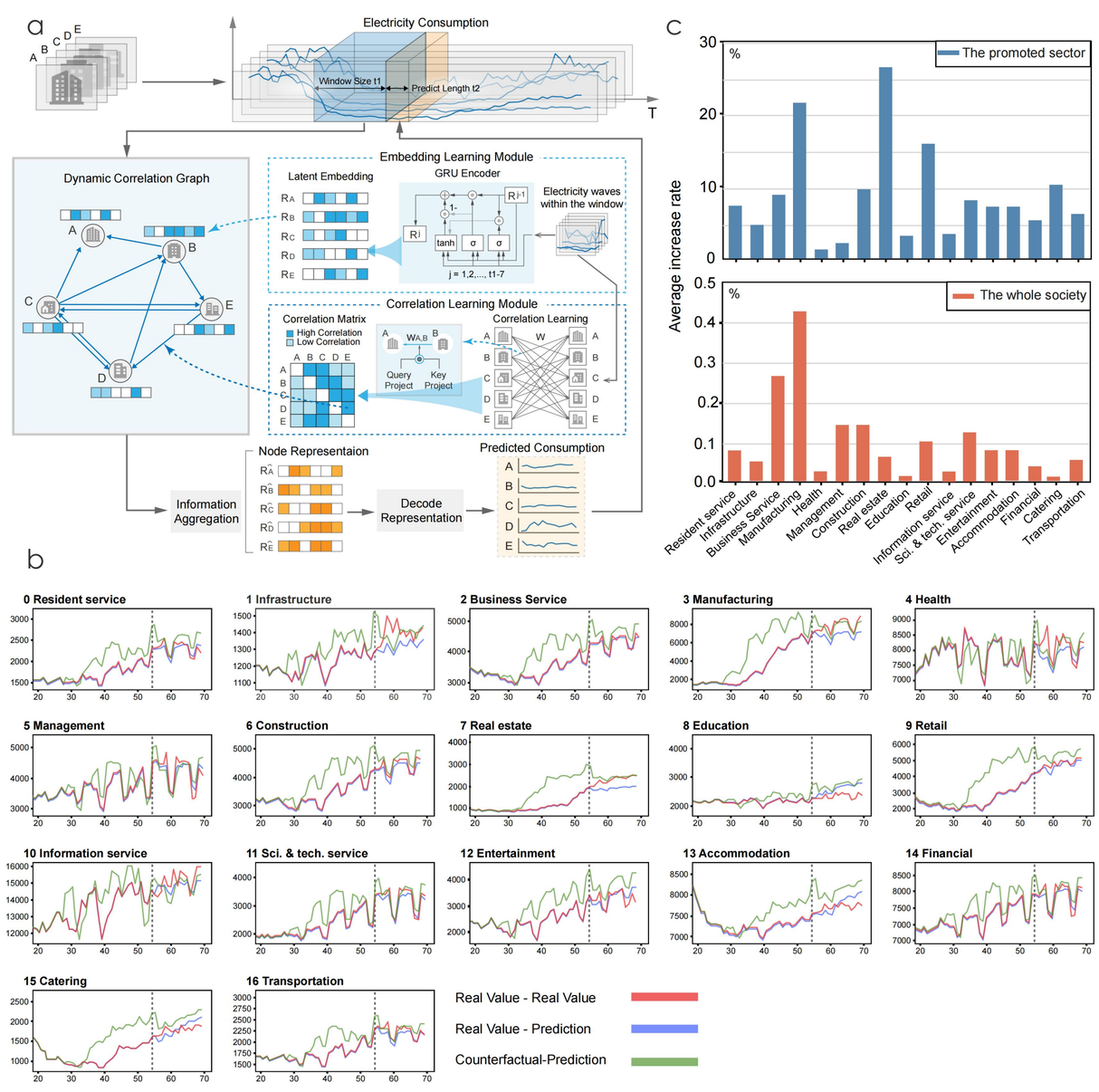
a) We plot the time points of policy issuance on the curve of the weekly recovery index to observe the impact of policies. Most of the policies are issued by Hangzhou or Zhejiang government from Jan. 21 to Aug. 31 2020, which are closely related to 17 main sectors.
b) We adopt the change-point detection algorithm to find out the sudden changes in each sector's recovery trend. Change points in the recovery index of education, entertainment, and catering sectors are detected to observe the effects of policies on each sector.

- The change point algorithm can give governments non-subjective, real-time feedback to support policy development.

For instance, we find that the policy of allowing students to return to school on a batch-by-batch basis firmly controlled the recovery of the education sector, allowing it to return steadily to its pre-epidemicstate; however, the policy of offering restaurant spending coupons only provided a short-lived boost to the catering sector, which remained depressed afterwards.

Model the Recovery Process

- How should we assign policy support to each sector? To address this question, we conduct simulation experiments based on our designed prediction model. The model predicts the future recovery trend of each sector precisely while capturing the correlation between sectors.



a) Model structure. We first build the correlation graph by simultaneously generate the graph node (organization) features (model the temporal information from organizations' electricity consumption sequence) and build the directed edges (based on the correlations between organizations calculated by correlation module). Then we conduct information aggregation on the learned graph and decode the aggregated representations to get predictions. b) The simulation values and model prediction results. c)The impact on the future recovery if we provide support to different sectors in the simulation experiments.

- Our study offers insights to policy-making that the government should not only consider the degree of depression in each sector but also take into account factors such as the sector characteristics and the interaction between sectors.

We hope that our research will help cities that are experiencing a COVID-19 lockdown recover more quickly afterward, and provide guidance for dealing with similar accidents that may arise in the future.

References

[1] Chinazzi, M. et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (covid-19) outbreak. Science 368, 395–400 (2020).
[2] Jamil, F. & Ahmad, E. The relationship between electricity consumption, electricity prices and gdp in pakistan. Energy policy 38, 6016–6025 (2010).
[3] Weible, C. M. et al. Covid-19 and the policy sciences: initial reactions and perspectives. Policy sciences 53, 225–241 (2020).
[4] Chang, S. et al. Mobility network models of covid-19 explain inequities and inform reopening. Nature 589, 82–87 (2021).
[5] Brand, S. P. C. et al. Covid-19 transmission dynamics underlying epidemic waves in kenya. Science 374, 989–994 (2021).
[6] Sheth, J. Impact of covid-19 on consumer behavior: Will the old habits return or die? Journal of Business Research 117, 280–283 (2020).
[7] Kaushal, V. & Srivastava, S. Hospitality and tourism industry amid covid-19 pandemic: Perspectives on challenges and learnings from india. International Journal of Hospitality Management 92, 102707 (2021).
[8] Gurgul, H. & Lach, Ł. The electricity consumption versus economic growth of the polish economy. Energy Economics 34, 500–510 (2012).
[9] McCartney, G., Pinto, J. & Liu, M. City resilience and recovery from covid-19: The case of macao. Cities 112, 103130 (2021).
[10] Lessler, J. et al. Household covid-19 risk and in-person schooling. Science 372, 1092–1097 (2021).
[11] LCho, K. et al. Learning phrase representations using rnn encoder-decoder for statistical machine translation. arXiv preprint arXiv:1406.1078 (2014).