

Capturing Spatial and Temporal Variation in Behaviors Related to COVID-19 using ENSIGN Reservoir Labs

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Nonpharmaceutical Interventions (NPIs)

“Nonpharmaceutical Interventions (NPIs) are actions, apart from getting vaccinated and taking medicine, that people and communities can take to help slow the spread of illnesses.”

Examples

Wearing Masks

Social Distancing

Limiting Mobility

Closures

Increased Hand Washing

Cleaning High-Touch Surfaces

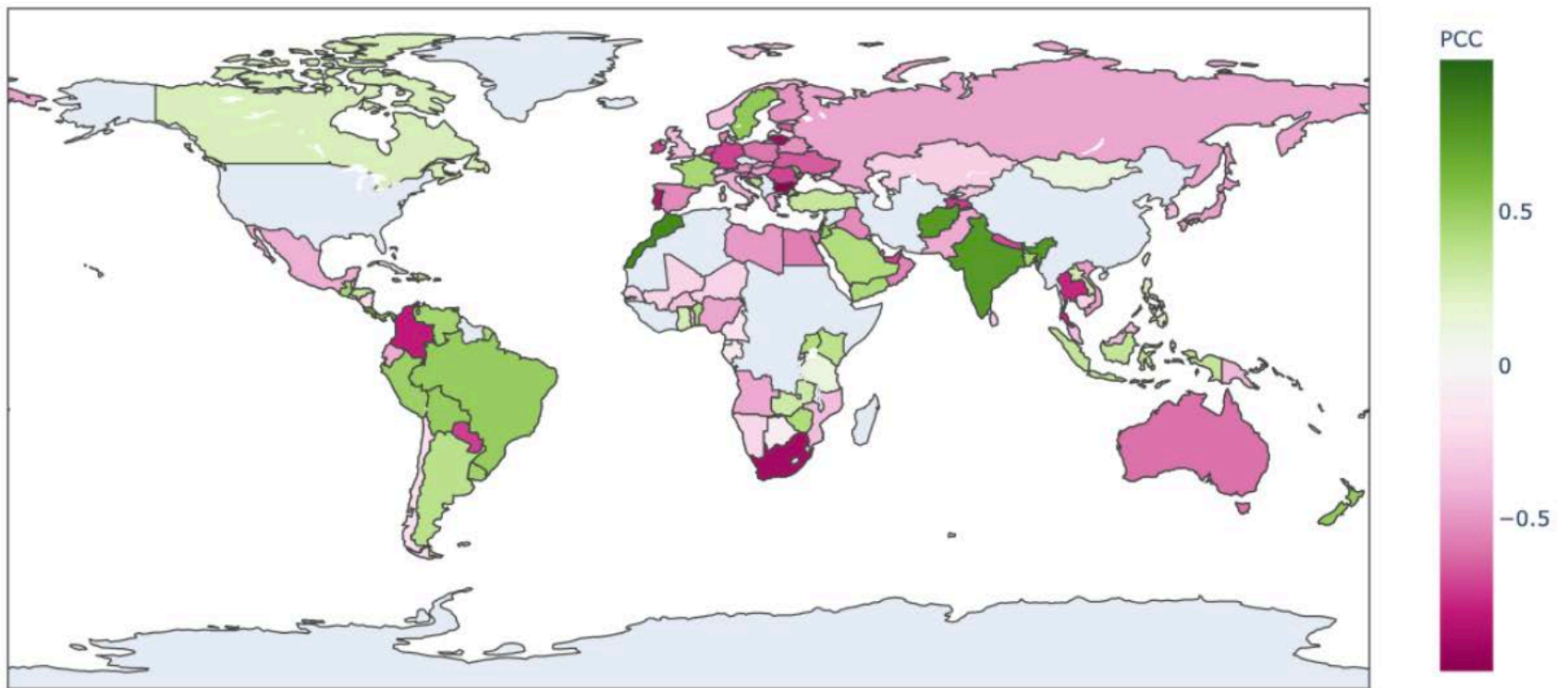
“NPIs are among the best ways of controlling pandemic illness when vaccines are not yet available.”

Source: <https://www.cdc.gov/nonpharmaceutical-interventions/index.html>


Efficacy Both Complicated and Complex

- Finding quality measurables connecting the many NPIs to adherence
- Understanding connections between policy, culture and outcomes

Decomposition-Identified Correlations Between Work Mobility and Cases in March



C3.ai Data Lake

 **C3 AI COVID-19 Data Lake**
Access unified, analysis-ready COVID-19 data, at no charge
<https://c3.ai/products/c3-ai-covid-19-data-lake/>



Google – Workplace Mobility Data



Johns Hopkins University – Daily Case Counts



University of Oxford –
Response Tracker (Closures)

```

1 country,date,work_closure,work_mobility,cases
2 Afghanistan,2020-02-15,0,-28,0
3 Afghanistan,2020-02-16,0,4,0
4 Afghanistan,2020-02-17,0,5,0
5 Afghanistan,2020-02-18,0,6,0
6 Afghanistan,2020-02-19,0,5,1
7 Afghanistan,2020-02-20,0,6,0
8 Afghanistan,2020-02-21,0,6,0
9 Afghanistan,2020-02-22,0,6,0
10 Afghanistan,2020-02-23,0,6,0
11 Afghanistan,2020-02-24,0,7,0
12 Afghanistan,2020-02-25,0,7,0
13 Afghanistan,2020-02-26,0,5,0
14 Afghanistan,2020-02-27,0,7,0
15 Afghanistan,2020-02-28,0,5,0
16 Afghanistan,2020-02-29,0,6,0
17 Afghanistan,2020-03-01,0,9,0
18 Afghanistan,2020-03-02,0,8,0
19 Afghanistan,2020-03-03,0,8,3
20 Afghanistan,2020-03-04,0,7,0

```

Combined Data – Merged, Binned and Ready to Decompose

ENSIGN: Tensor Decompositions at Scale

```
In [30]: import numpy as np
import pandas as pd

import ensign.sptensor as spt
import ensign.csv2tensor as c2t
import ensign.cp_decomp as cpd
import ensign.visualize as viz
```

```
In [31]: work_data = pd.read_csv('data/work_mobility_adherence_cases.csv')
work_data
```

Out[31]:

	country	date	work_closure	work_mobility	cases
0	Afghanistan	2020-02-15	0	-28	0
1	Afghanistan	2020-02-16	0	4	0
2	Afghanistan	2020-02-17	0	5	0
3	Afghanistan	2020-02-18	0	6	0
4	Afghanistan	2020-02-19	0	5	1
...
24134	Zimbabwe	2020-08-24	1	-15	18
24135	Zimbabwe	2020-08-25	1	-16	6
24136	Zimbabwe	2020-08-26	1	-16	85
24137	Zimbabwe	2020-08-27	1	-16	62
24138	Zimbabwe	2020-08-28	1	-15	79

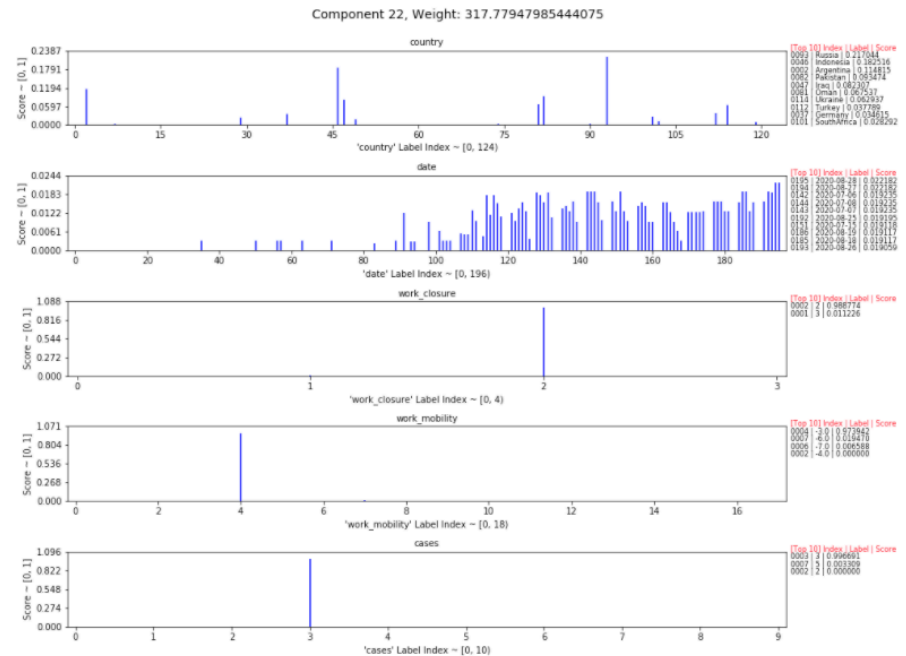
24139 rows x 5 columns

```
In [32]: tensor = c2t.csv2tensor('data/work_mobility_adherence_cases.csv',
columns=['country', 'date', 'work_closure', 'work_mobility', 'cases'],
types=['str', 'date', 'int64', 'int64', 'int64'],
binning=['none', 'none', 'none', 'binsize=10', 'log10'])
```

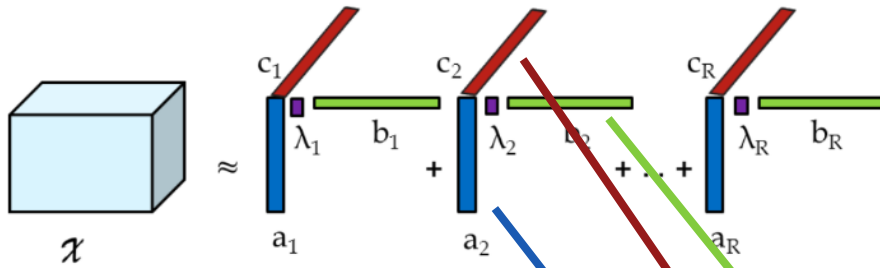
```
In [33]: decomp = cpd.cp_apr(tensor, 100)
```

```
In [34]: %matplotlib inline
viz.plot_component(decomp, 22)
```

Out[34]:



Revealing Patterns and Correlations



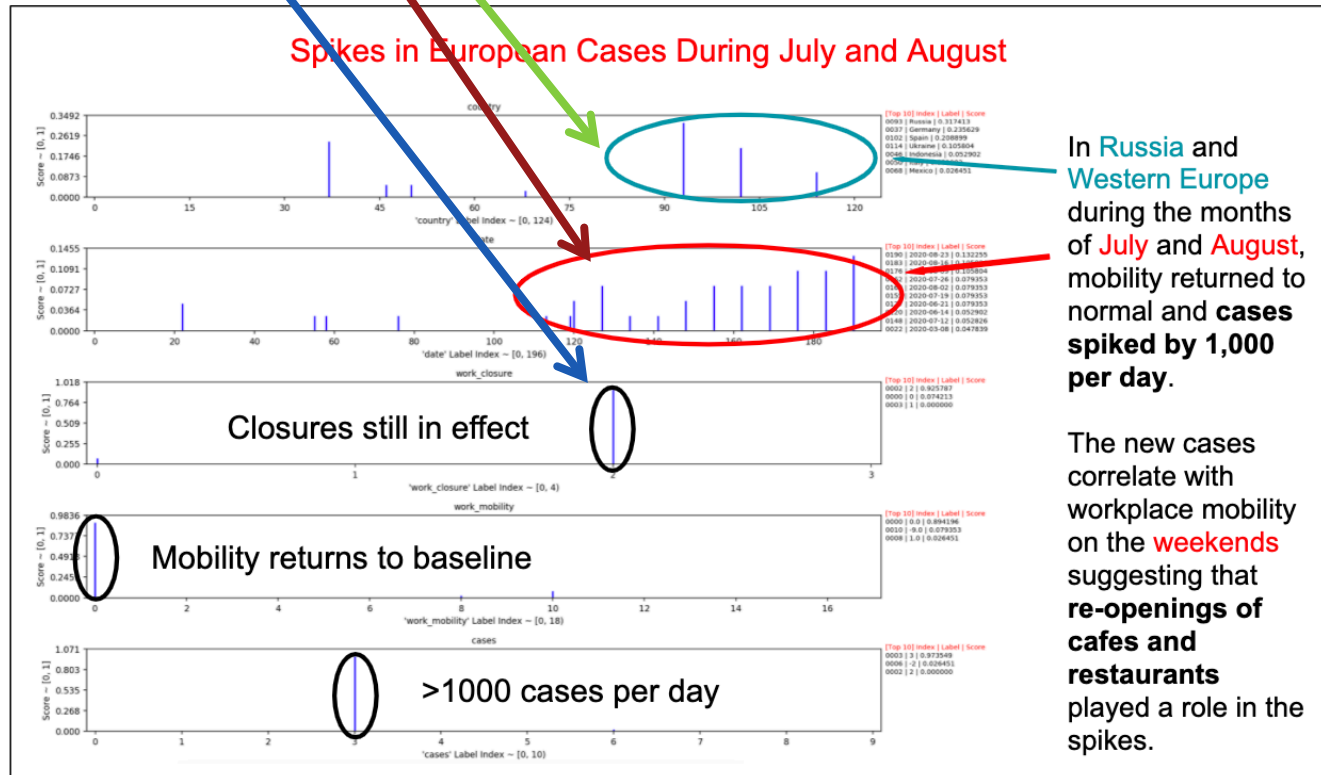
Country

Date

Policy

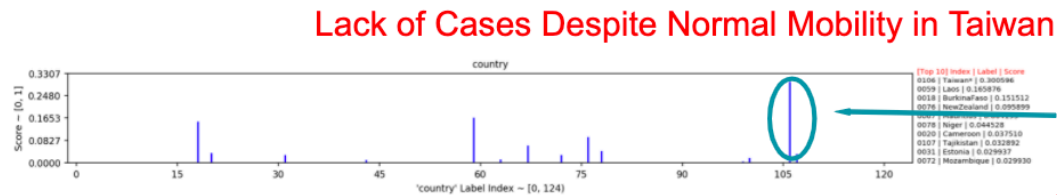
Mobility

Cases

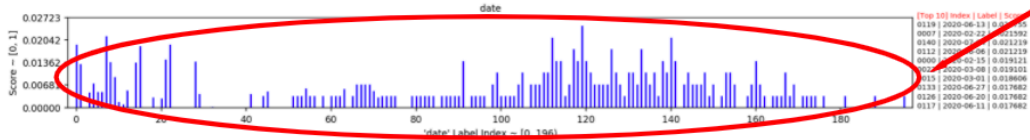


Revealing Patterns and Correlations

Country



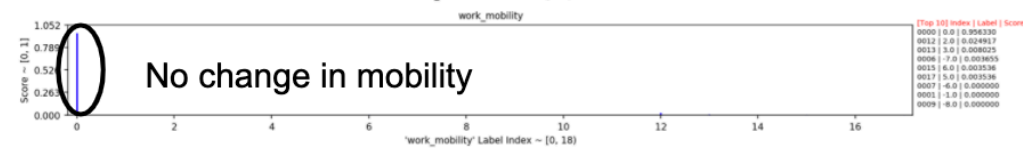
Date



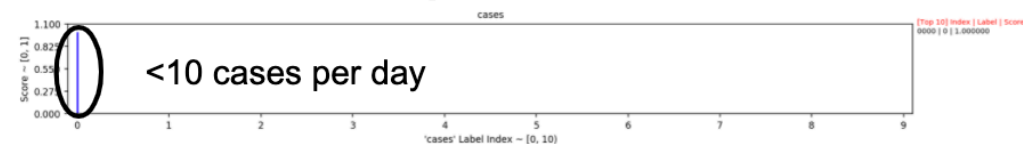
Policy



Mobility



Cases



In Taiwan throughout the entire duration of the pandemic, there were no changes in workplace mobility yet there were very few cases per day.

Therefore some other non-pharmaceutical intervention is needed to explain the lack of cases in Taiwan.

Decompositions Find Pandemic Phases

Capturing Spatial and Temporal Variation in Behaviors and Cases

Behavior of **all countries pre-pandemic** clustered in a single component



Behavior of **Central European countries** during **April and May**



Behavior of **Eastern European and Middle Eastern countries** during **May and June**



Behavior of **Central American countries** during **July and August**



Conclusion

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- Chi, E., Kolda, T., **On Tensors, Sparsity, and Nonnegative Factorizations**, *SIAM Journal on Matrix Analysis and Applications* 33.4 (2012):1272-1299

ENSIGN 4.3

- *Decompositions*
 - *Shared and Distributed Memory*
- *Tensor formation and post-processing tools*
- *Python 3 API*
- Available for Government & Research Use

Relevant Papers

- *Multiscale Data Analysis Using Binning, Tensor Decompositions, and Backtracking*
HPEC, Sep 2020
- *Fast and Scalable Distributed Tensor Decompositions*
HPEC, Sep 2019
- *A Quantitative and Qualitative Analysis of Tensor Decompositions on Spatiotemporal Data*
HPEC, Sep 2017