Saving Lives versus Saving Livelihoods: Can Big Data Technology Solve the Pandemic Dilemma?

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COVID-19 and Economics: China, Asia and Beyond

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Motivation

- COVID-19: an impossible choice between saving lives and saving livelihoods
- Population movement restrictions are deemed necessary to contain pandemics
- But such restrictions inflict steep economic costs
- U.S. GDP is foretasted to decline at a 37% annual rate from April to June (WSJ, April 29)

How do we solve the pandemic dilemma?

Table 1: Top 10 Most Downloaded Contact-Tracing Apps

Country	App Name	Downloads
India	Aarogya Setu	50M
Czech Republic	Mapy.cz	1M
Colombia	CoronApp	1M
South Korea	Corona 100m	1M
Israel	The Shield	1M
Singapore	TraceTogether	0.5M
India (Punjab)	COVA Punjab	0.5M
Spain (Catalonia)	STOP COVID19 CAT	0.5M
Norway	Infection Stop	0.1M

Big Data Technology

- Advocates
  - Detect potential carriers and allow the mass population to resume work
  - Successful experience in China and South Korea
- Critics
  - Inconclusive evidence: unsuccessful experience in Singapore
  - Privacy infringement and government surveillance

This paper

- Exploit the staggered adoption of contact-tracing apps in 322 Chinese cities
- Use high-frequency measures of economic activities
  - Within-city population movements
  - Emission of greenhouse gas

Findings

- Cities that adopt contact-tracing apps experience a significant increase in economic activities without suffering from higher infection rates
- Contact-tracing apps create an economic value of 0.5%-0.75% of GDP during the COVID-19 outbreak
- The economic benefits seem to outweigh the cost of privacy

Institutional Background

Contact-Tracing Apps: Health Code

- Green: no restriction
- Yellow: isolation for 7 days (then it turns green)
- Red: isolation for 14 days (then it turns green)

Contact-Tracing Apps: Health Code

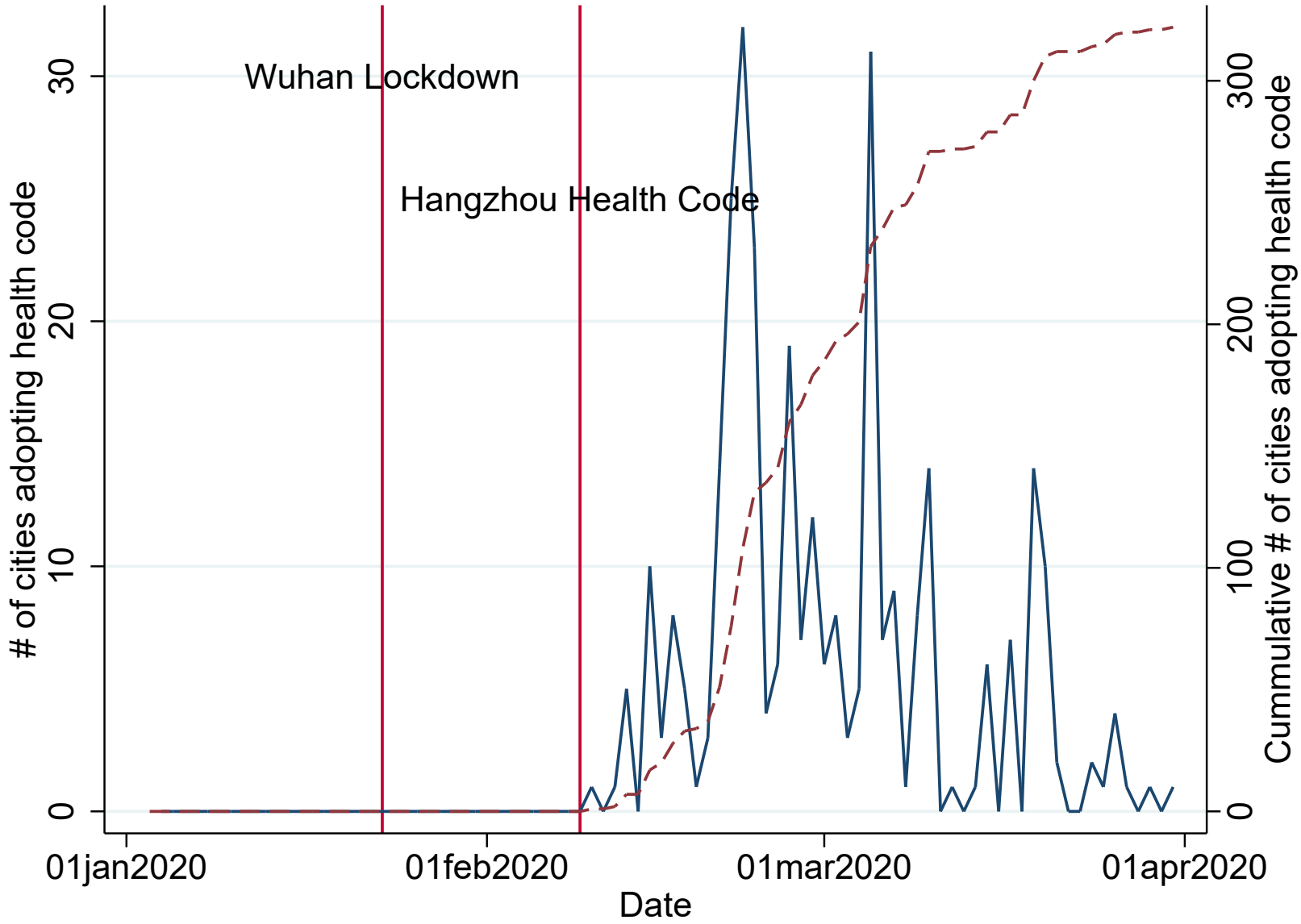
- First implemented in Hangzhou on Feb 11, 2020
- Implemented by other cities in a staggered manner
- The implementation is uncoordinated by the central government
- Cities often have different versions of health code

Data

Data

- **Implementation dates of health code for 322 cities in China**
- Within-city population movements
- Greenhouse gas level of each city
- Daily COVID-19 infection counts for 322 cities in China

Adoption of Health Code in Chinese Cities



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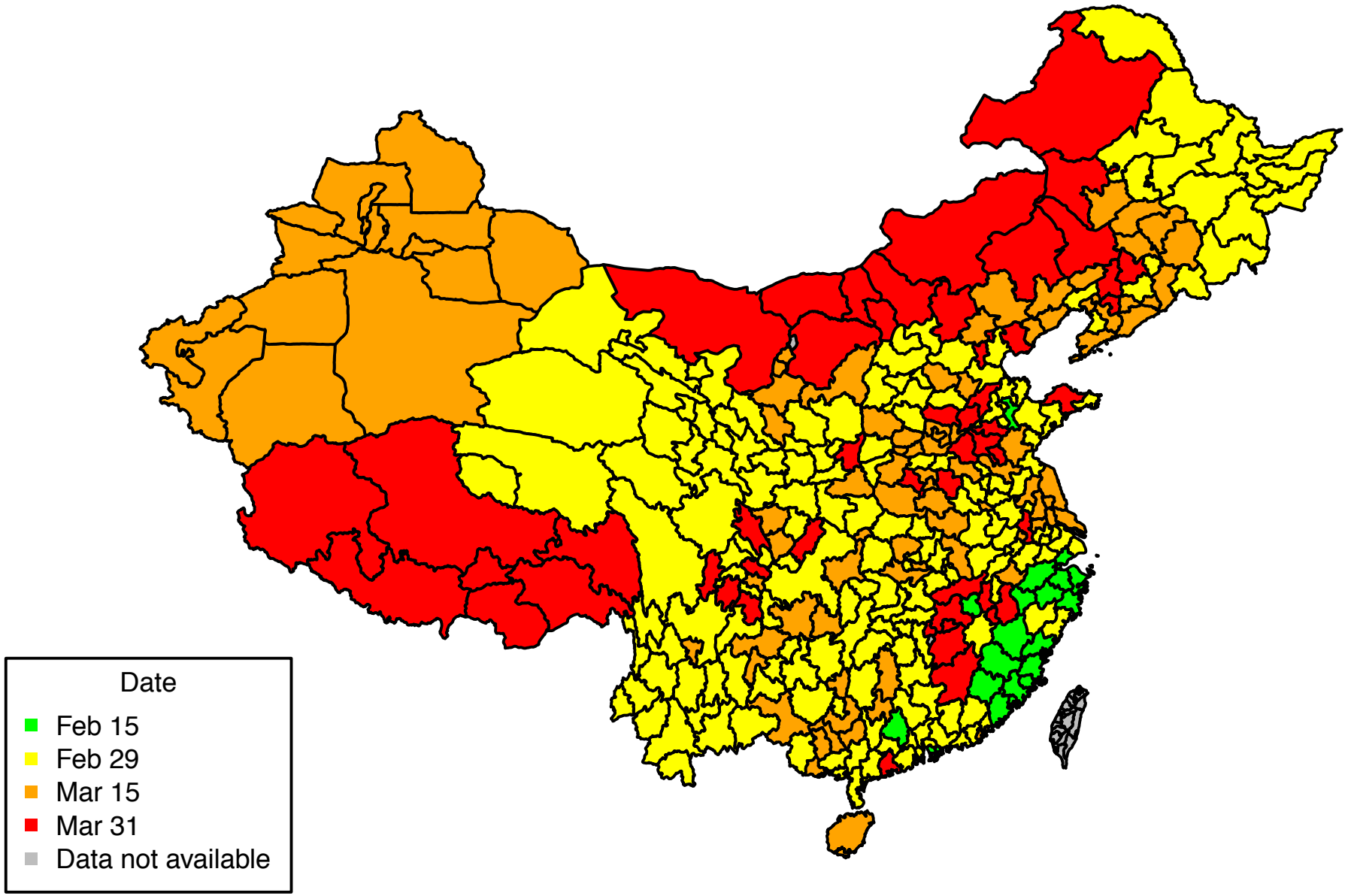

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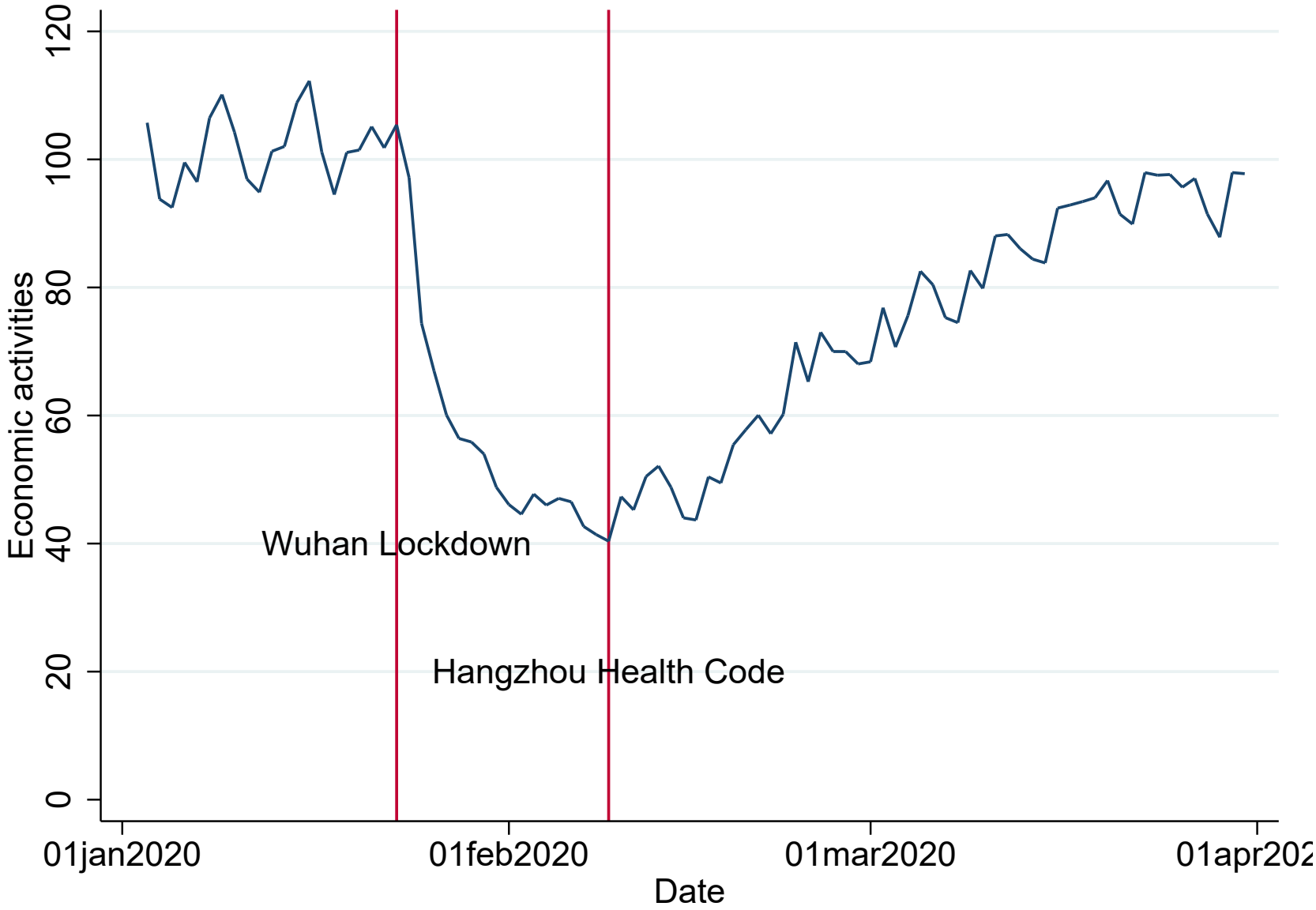
Economic Activities of Chinese Cities



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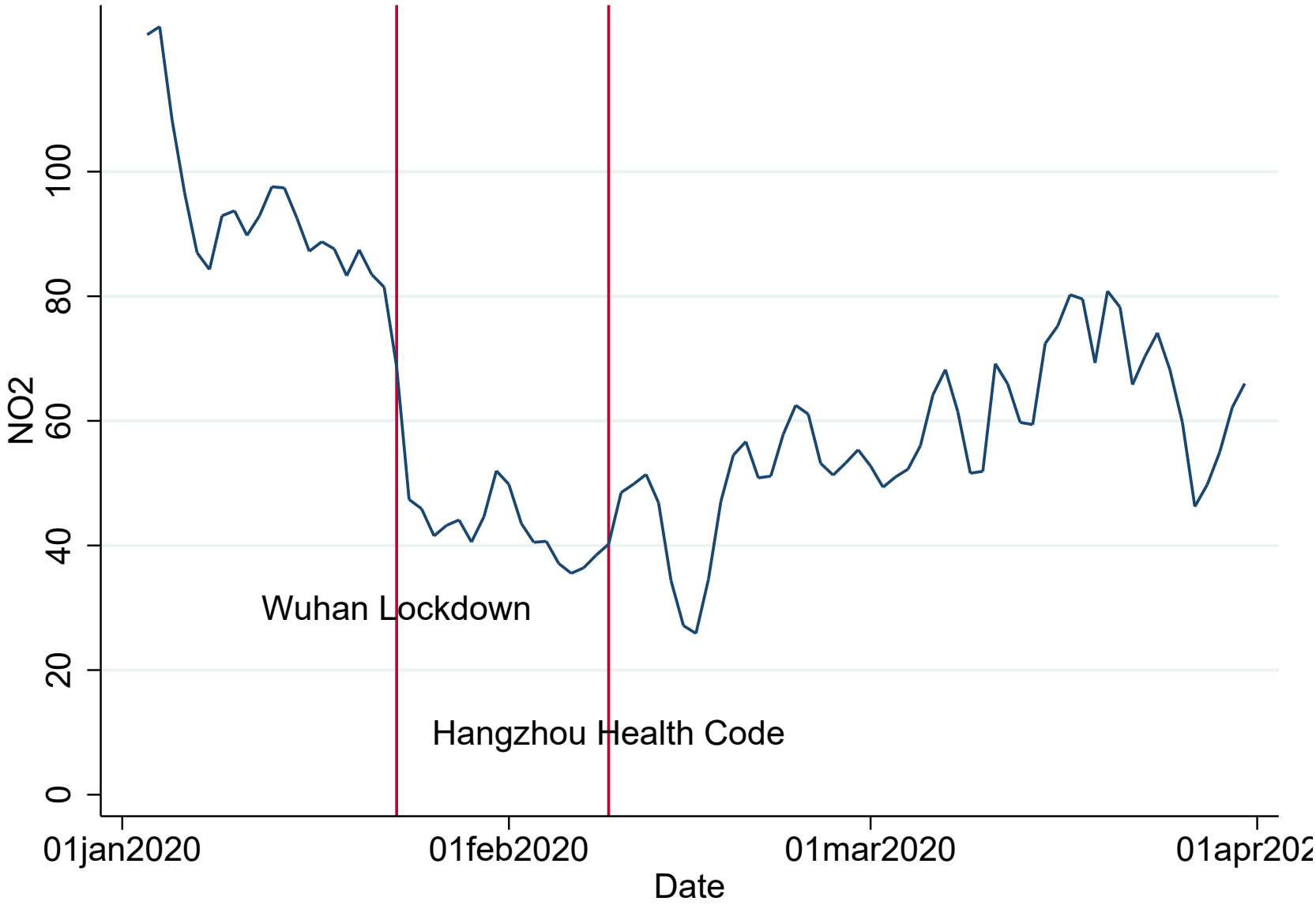
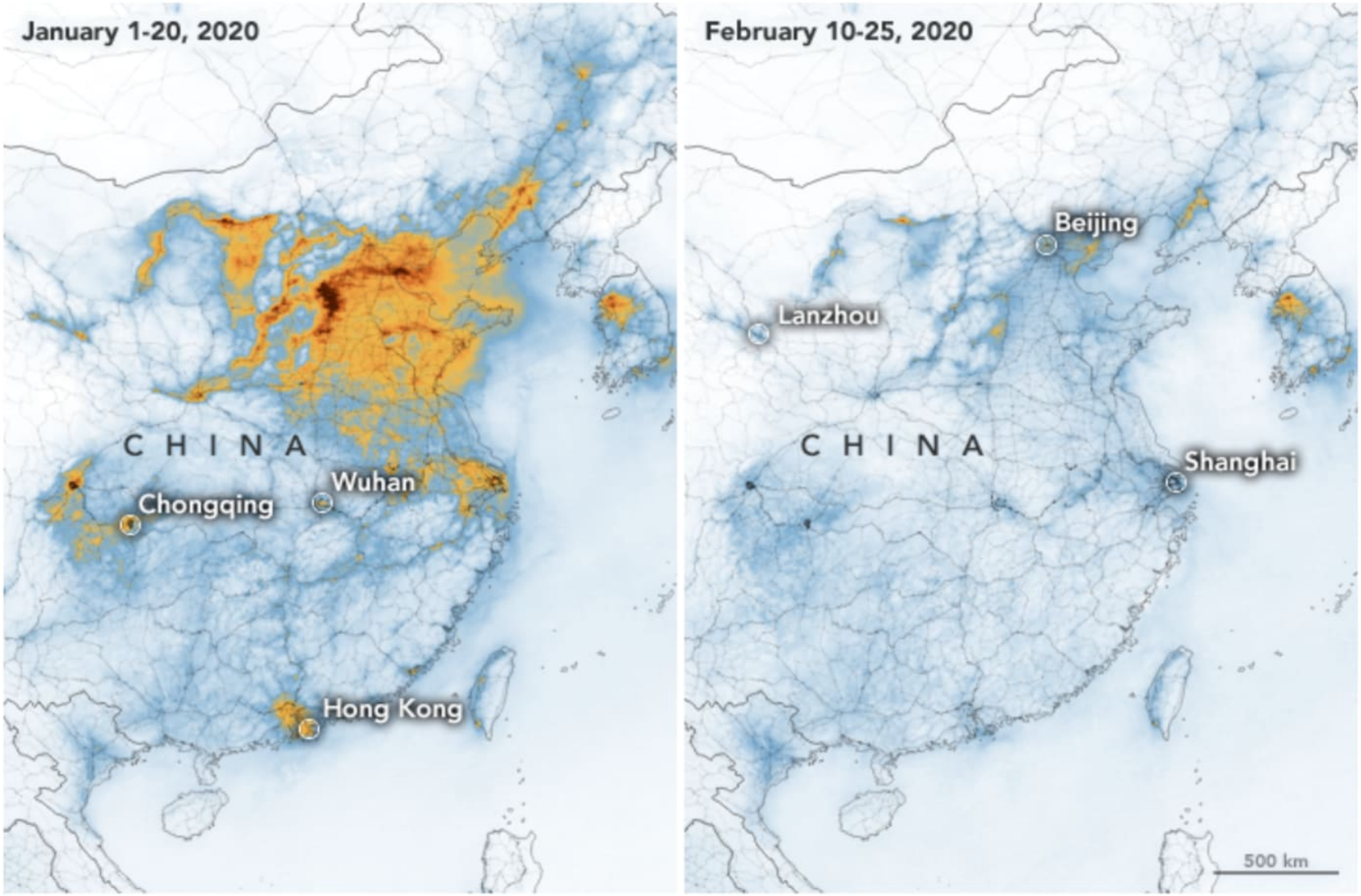
Nitrogen Dioxide Level of Chinese Cities



Nitrogen Dioxide Level of Chinese Cities from NASA



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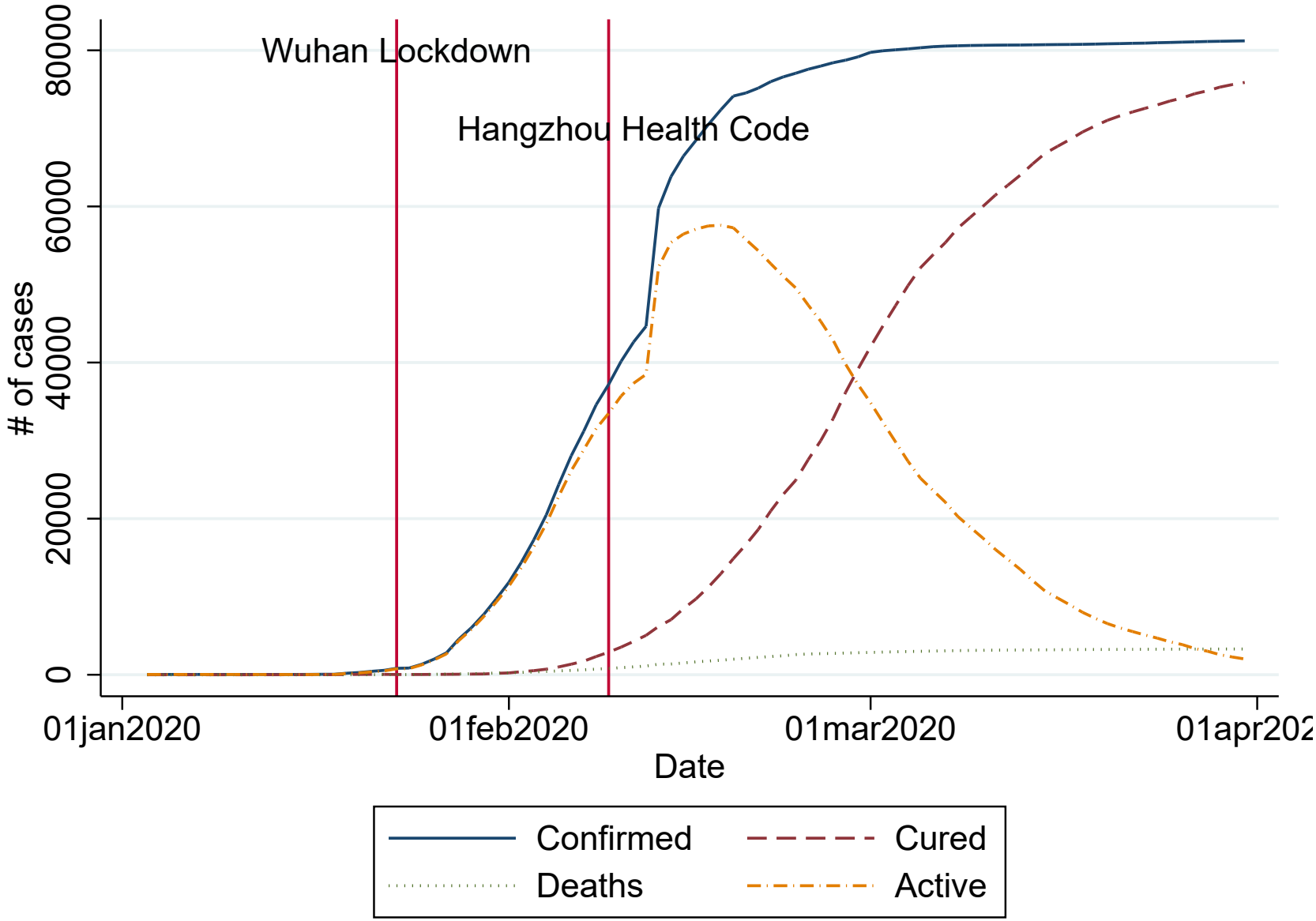
Nitrogen Dioxide Level of Chinese Cities



Summary Statistics

	N	mean	sd	p5	p25	p50	p75	p95
Within-city movements	28658	78	26	32	56	84	99	109
NO2	24742	63	30	23	40	58	81	119
PM2.5	24742	78	51	20	43	68	102	171
Infection rate	28658	2	5	0	0	0	0	20
Confirmed cases	28658	144	1986	0	0	8	31	213
Cured cases	28658	83	1252	0	0	3	18	140
Deaths	28658	5	91	0	0	0	0	3
Emergency level	28658	2	1	0	0	2	3	3

Results

Effect of Health Code on Within-city Movement

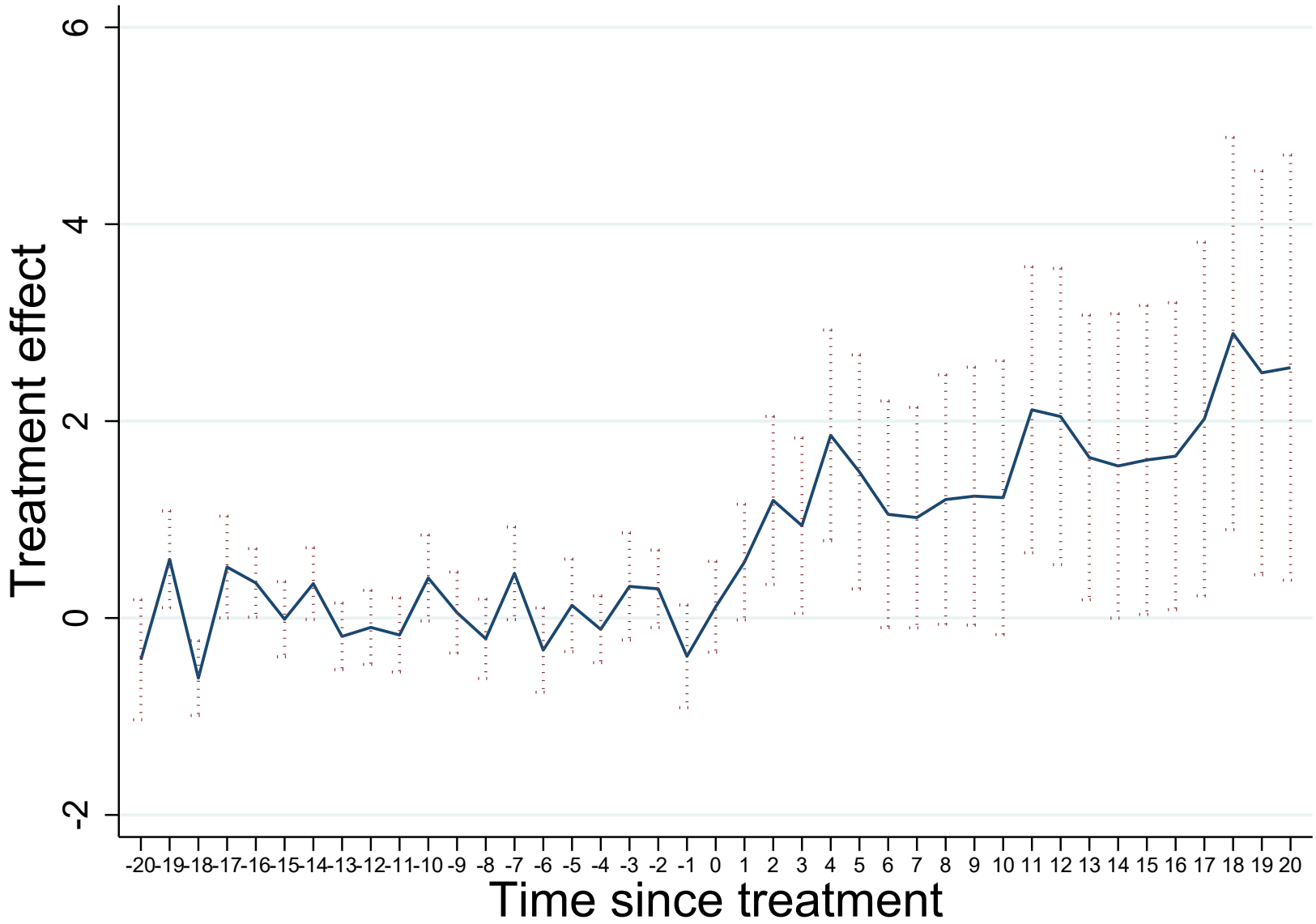
- Regression model

$$\text{EconomicActivity}_{i,t} = \beta \text{HealthCode}_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}$$

	(1) Movement	(2) Movement	(3) Movement	(4) Movement
Health code	2.859***	2.687***	2.552***	3.118***
	[0.410]	[0.345]	[0.437]	[0.399]
Control	Yes	Yes	Yes	Yes
City F.E.	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes
Emergency F.E.	Yes	Yes	Yes	Yes
Sample	Full sample	Excl. Hubei	Match by cases	Match by act.
Observations	28,658	27,145	28,658	28,658
Adj. R-squared	0.852	0.862	0.867	0.852

- The introduction of health code leads to around 2-3% increase in within-city movement.

Dynamic Effect of Health Code on Economic Activities



Effect of Health Code on Greenhouse Gas

- Regression model

$$\text{EconomicActivity}_{i,t} = \beta \text{HealthCode}_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}$$

	(1) NO2	(2) NO2	(3) NO2	(4) NO2
Health code	1.792*	1.973*	1.417	1.980**
	[1.006]	[1.057]	[1.106]	[0.990]
Control	Yes	Yes	Yes	Yes
City F.E.	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes
Emergency F.E.	Yes	Yes	Yes	Yes
Sample	Full sample	Excl. Hubei	Match by cases	Match by act.
Observations	24,742	23,674	24,742	24,742
Adj. R-squared	0.541	0.534	0.555	0.541

- The introduction of health code leads to around 2% increase in NO2 level.

Effect of Health Code on Greenhouse Gas

- Regression model

$$\text{EconomicActivity}_{i,t} = \beta \text{HealthCode}_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}$$

	(1) PM2.5	(2) PM2.5	(3) PM2.5	(4) PM2.5
Health code	4.989***	4.830***	4.514*	5.152***
	[1.671]	[1.767]	[2.287]	[1.626]
Control	Yes	Yes	Yes	Yes
City F.E.	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes
Emergency F.E.	Yes	Yes	Yes	Yes
Sample	Full sample	Excl. Hubei	Match by cases	Match by act.
Observations	24,742	23,674	24,742	24,742
Adj. R-squared	0.358	0.352	0.378	0.360

- The introduction of health code leads to around 4% increase in PM2.5 level.

Effect of Health Code on Between-city Migration

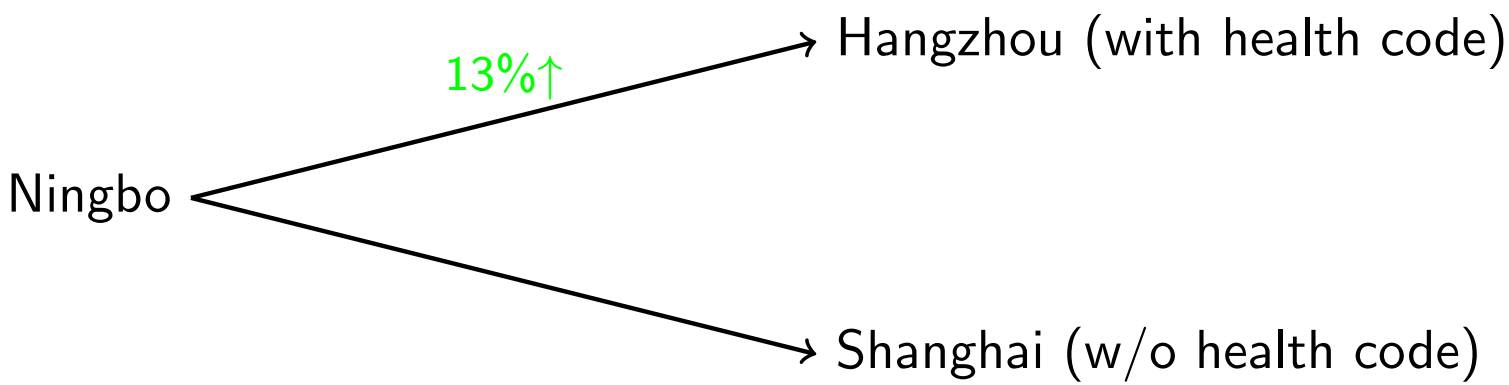
- Regression model

$$\text{Inflow}_{i,j,t} = \beta \text{DestinationHealthCode}_{j,t} + \gamma X_{i,j,t} + \epsilon_{i,t},$$

	(1) Inflow	(2) Inflow	(3) Inflow	(4) Inflow
Health Code (destn)	12.694***	13.185***	11.183***	12.557***
	[1.700]	[1.696]	[1.709]	[1.687]
Control	Yes	Yes	Yes	Yes
City pair F.E.	Yes	Yes	Yes	Yes
Source-time F.E.	Yes	Yes	Yes	Yes
Emergency level F.E.	Yes	Yes	Yes	Yes
Sample	Full sample	Excl. Hubei	Match by cases	Match by act.
Observations	1,888,652	1,798,439	1,888,652	1,888,652
Adj. R-squared	0.857	0.859	0.863	0.858

- The introduction of health code increases inflows to a city.

Effect of Health Code on Between-city Migration: Inflows



Effect of Health Code on Between-city Migration

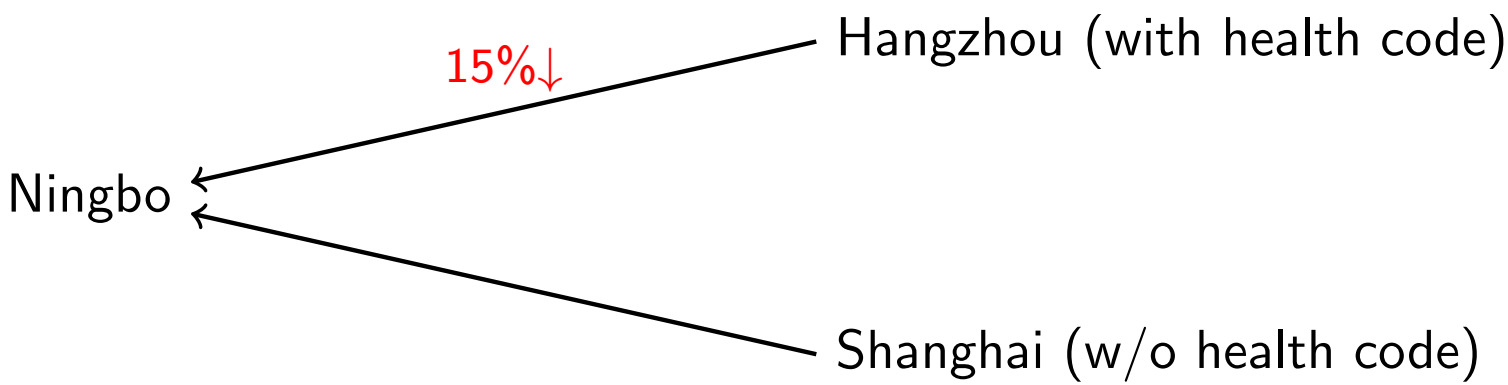
- Regression model

$$\text{Outflow}_{i,j,t} = \beta \text{SourceHealthCode}_{i,t} + \gamma X_{i,j,t} + \epsilon_{i,t}$$

	(1) Outflow	(2) Outflow	(3) Outflow	(4) Outflow
Health Code (source)	-14.840***	-14.647***	-13.681***	-14.549***
	[1.778]	[1.744]	[1.612]	[1.749]
Control	Yes	Yes	Yes	Yes
City pair F.E.	Yes	Yes	Yes	Yes
Destination-time F.E.	Yes	Yes	Yes	Yes
Emergency level F.E.	Yes	Yes	Yes	Yes
Sample	Full sample	Excl. Hubei	Match by cases	Match by act.
Observations	1,887,544	1,834,631	1,887,544	1,887,544
Adj. R-squared	0.860	0.862	0.861	0.860

- The introduction of health code in the source city decrease flows from a city.

Effect of Health Code on Between-city Migration: Outflows



Effect of Health Code on Infection Rates

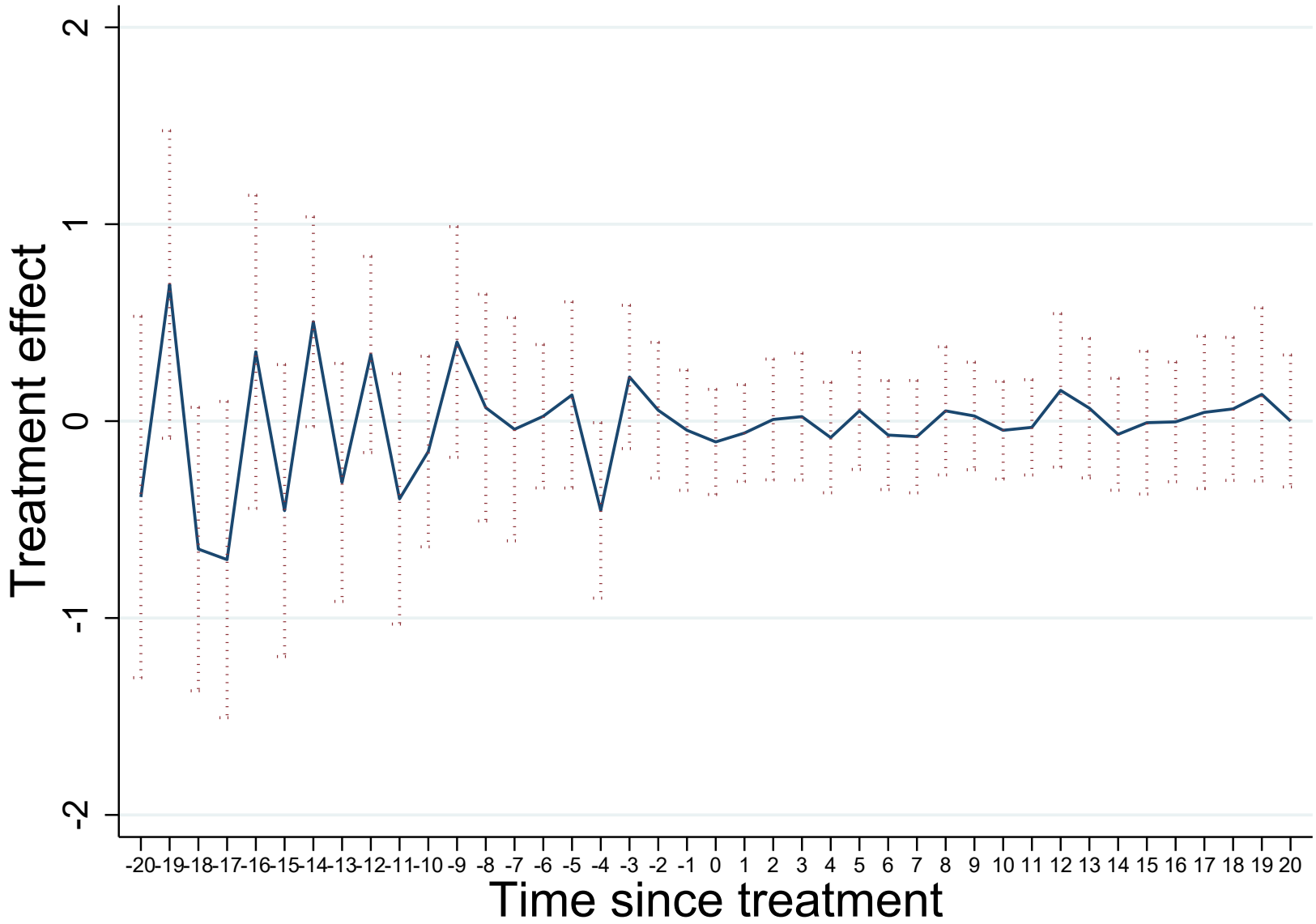
- Regression model

$$\text{InfectionRate}_{i,t+7} = \beta \text{HealthCode}_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}$$

	(1) Infection rate	(2) Infection rate	(3) Infection rate	(4) Infection rate
Health code	0.024	0.028	-0.000	0.027
	[0.078]	[0.081]	[0.092]	[0.082]
Control	Yes	Yes	Yes	Yes
City F.E.	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes
Emergency F.E.	Yes	Yes	Yes	Yes
Sample	Full sample	Excl. Hubei	Match by cases	Match by act.
Observations	26,404	25,010	26,404	26,404
Adj. R-squared	0.411	0.388	0.412	0.408

- The introduction of health code does not lead to a significant increase in infection rates.

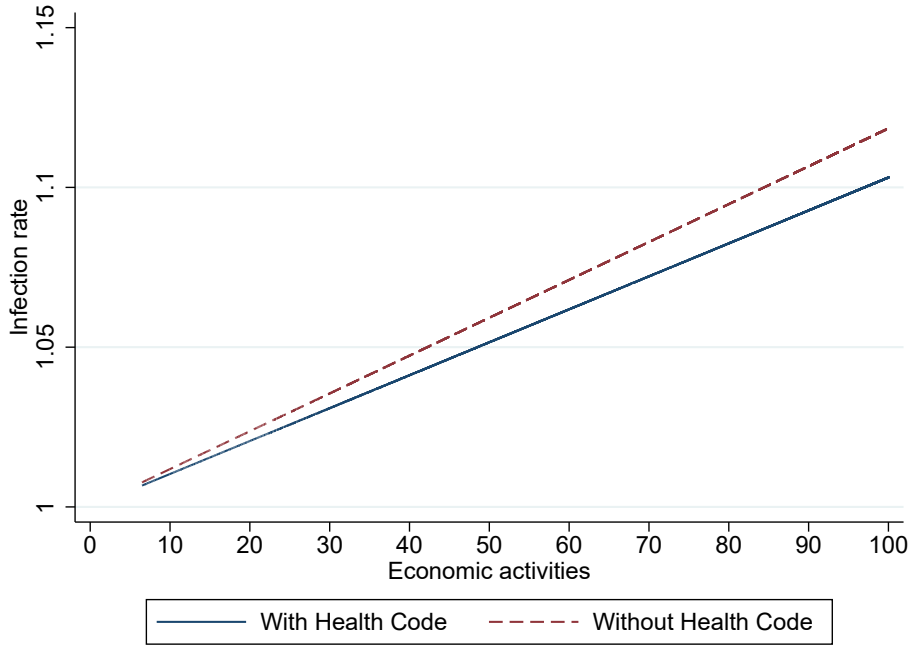
Dynamic Effect of Health Code on Infection Rates



Saving Lives vs. Saving livelihood

- Regression model

$$\text{InfectionRate}_{i,t+7} = \beta_1 \text{HealthCode}_{i,t} \times \text{EconomicActivity}_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}$$



- Without health code, economic activities have to decrease by 19% to reduce the daily infection rate by 1% from its average level.
- With health code, economic activities only need to decrease by 17% to achieve the same amount of reduction in infection rate.

Do Benefits Justify Costs?

- 2-3% increase in economic activities
- The outbreak lasted for a quarter in China
- Health code creates an economic value of 0.5%-0.75% GDP
- Chinese GDP per capita: $10,000
- Economic value per person: $50 – $75
- Value of privacy: $33 (Huang, 2019)
- Caveat 1: culture differences in value of privacy (Athey et al, 2017)
- Caveat 2: data anonymization

Why Is Big Data Effective in Fighting Pandemics?

- The key amplification mechanism: incomplete information
- Because of the hidden virus, people are afraid of going out, which brings economy actitivities to a standstill
- Governments have to impose quarantines on the whole population just to stop a few hidden carriers
- Big data technology can effectively alleviate information frictions

Conclusion

- Cities adopt contact-tracing apps experience a significant increase in economic activities without suffering from higher infection rates
- Contact-tracing apps create an economic value of 0.5%-0.75% of GDP during the COVID-19 outbreak
- The economic benefits seem to outweigh the cost of privacy