Plunge and rebound of a taxi market through COVID-19 lockdown: Lessons learned from Shenzhen, China.

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Introduction

The COVID-19 pandemic began to sweep through the world in early 2020. Few industry is hit as hard as transit (massive ridership drop, slow recovery). It's critical to understand when, where and how a pandemic inflicts damages on both the supply and demand of various transit services.

Contribution

- ❑ Document the plunge and rebound of the **taxi demand** through a **spatiotemporal analysis**.
- ❑ Reveal taxi drivers' **operational strategies** through a **clustering analysis**.
- ❑ Trace the industry's **level of service**.
- ❑ Evaluate the city government's **taxi subsidy policies**.

Data description

Overview

- "City Of Shenzhen Taxi" (COST) data include GPS trajectories of all registered taxis in Shenzhen, China.
- Raw data are processed to generate occupied and search trips using the method described in Nie (2017).

Table 1: Estimated passenger waiting time in the four weeks (min).

Week	Period	#Taxis	GPS points (million)
1. Benchmark	01/01/2020-01/07/2020	20,427	262.18
2. Initial lockdown	01/27/2020-02/02/2020	12,300	194.91
3. Phased reopening	02/14/2020-02/20/2020	12,006	172.09
4. Full reopen (except schools)	03/16/2020-03/22/2020	19,044	282.68

Study period

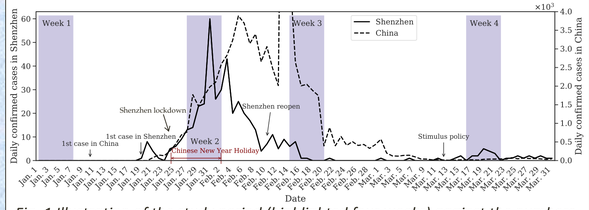


Fig. 1 Illustration of the study period (highlighted four weeks) against the numbers of daily confirmed COVID-19 cases in Shenzhen and China.

Government's taxi subsidy policies

- **¥4,000 per taxi per month** whether they choose to work or not, which is **less than half** of the operation cost (¥9,000 per month).
- **¥50 reward if a driver operates up to 100 km/5 hours a day** after March 12, 2020.

Demand analysis

Ridership

- 85% loss in W2 and W3.
- More than 50% below normal in W4.
- **Recover slower than overall vehicle trips** (estimated by average speed).

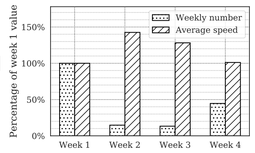
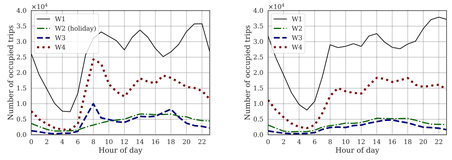


Fig.2 Weekly number and average speed of occupied taxi trips relative to Week 1.

Temporal distribution



(a) Weekday (Tuesday) (b) Weekend (Saturday)

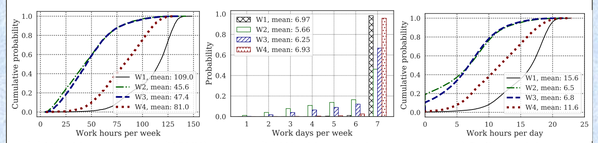
Fig.3 Number of hourly occupied taxi trips in the four weeks.

- Recover the fastest in rush hour (07:00 - 09:00 AM).
- W2 sees no difference between weekday and weekend.
- W3 and W4 show a clear "weekday pattern" (Fig. 3a).

Supply analysis

- Analysis group: 5,021 taxis that made at least ten occupied trips in each of the four weeks.

Work schedule

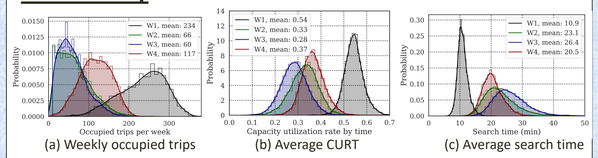


(a) Weekly work hours (WWH) (b) Weekly work days (c) Daily work hours

Fig.4 Work schedules of the selected 5,021 taxis in the four weeks.

- Most drivers still worked seven days a week, though 60% less hours in W2 and W3.

Productivity



(a) Weekly occupied trips (b) Average CURT (c) Average search time

Fig.5 Productivity metrics of the 5,021 taxis in the four weeks.

- The maximum weekly occupied trips remains the same after COVID (40% lower than the one in W1, see Fig. 5a).
- The taxi productivity reached the lowest point in W3, and slowly recovered afterwards.

Taxi clustering analysis

- Algorithm: K-mean clustering.
- Features: weekly work hours (WWH) and the capacity utilization rate by time (CURT). Eight in total.

Results

Table2: 5,021 taxis are clustered into four groups.

Cluster	# taxi	Character
I	1,221	The most dedicated taxi drivers
II	1,556	The most responsive to the crisis
III	1,210	Work habit permanently changed by COVID-19
IV	1,034	The most "laid back" group

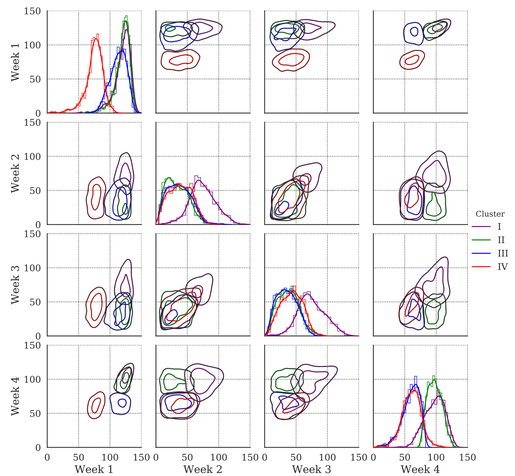


Fig.6 Clustered two-dimensional analysis of taxi weekly work hours. In each plot, both x and y axes represent WWH in one of the four weeks. Off-diagonal subplots are bivariate kernel density functions of WWH corresponding to the two different weeks on its axes, while diagonal plots show the PDFs of WWH in each week.

Level of service

- Measured by expected passenger wait time (EPWT).
- EPWT in five local markets are estimated following Zhang et al. (2019)

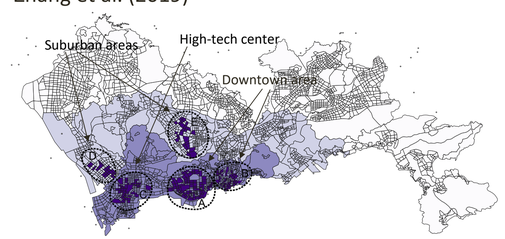


Fig.7 Distribution of five selected core areas in Shenzhen.

Table 3: Estimated passenger waiting time in the four weeks (min).

Core areas	A	B	C	D	E
Week 1	2.3	1.8	3.2	6.3	2.7
Week 2	4.4	2.7	9.6	17.6	7.4
Week 3	4.5	2.5	7.3	16.0	6.0
Week 4	***2.0***	***1.5***	***2.9***	***5.2***	***2.3***

Findings

- EPWT nearly tripled in C and D in W2 and W3.
- Downtown area (A and B) suffers less loss of LOS.
- **In W4, LOS exceeded the pre-COVID level in all areas.**

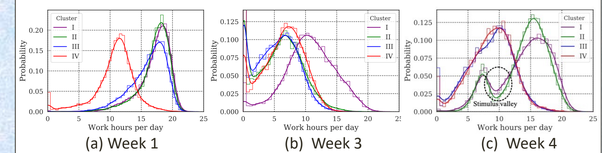
Hypothesis: The taxi subsidy policy partially contributes to the oversupply (hence the unnecessarily high LOS) in W4.

Indirect evidence

- The policy took effect right before W4.
- Taxi travel in W4 is less than half of the normal level, while average WWH is at 75% of the normal level.
- Operational efficiency in W4 is much lower than W1: the average search time is twice as long and the capacity utilization rate is 30% lower.

Direct evidence

- If drivers are indeed "lured" into service by the bonus, they might work as long as the reward requirement (**5 hours per driver**) is met.
- Each taxi is often operated by two drivers.
- A **stimulus valley around 10 hours per taxi** is found in the distribution of taxi daily work hours particularly in W4.



(a) Week 1 (b) Week 3 (c) Week 4

Fig.8 Distribution of average daily work hours (DWH) for the four taxi clusters.

Policy implications

- Incentives aiming at boosting supply should more **precisely target where the boost is most needed**.
- **The taxi market conditions should be closely monitored** to support and adjust policies.
- When the demand is severely depressed by lockdown orders or when the market is oversupplied, **taxi drivers should be encouraged and aided to use more centralized dispatching modes.**

Zheng, H., Zhang, K. and Nie, Y.M. (2021). Plunge and rebound of a taxi market through COVID-19 lockdown: Lessons learned from Shenzhen, China. *Transportation Research Part A: Policy and Practice*, 150, pp.349-366.