Impacts of Ride-hailing on Urban Mobility

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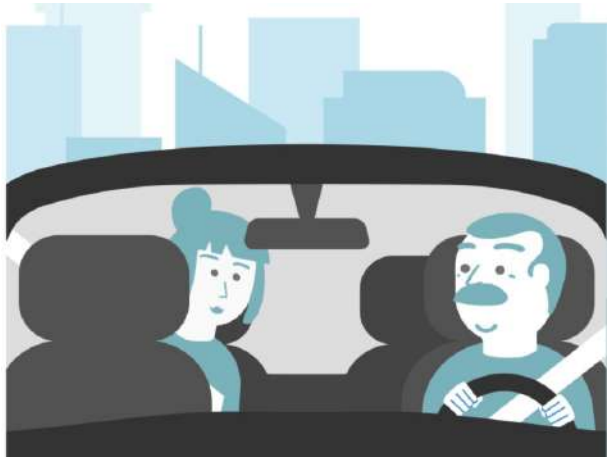
Ride-hailing

- **Ride-hailing** refers to transportation services that connect drivers with passengers via mobile devices and applications. The drivers drive private cars instead of commercial vehicles.
- Services provided by Uber, Lyft, DiDi (in China), Grab (in Southeast)…
- sharing economy: ‘access to use’ instead of ‘ownership’

Ride-hailing

Specifically, we differentiate exclusive vs. shared ride-hailing services –



Exclusive (or private) ride-hailing: a driver is paired with a single rider (or rider party) serving a single trip (e.g. UberX, Lyft, JustGrab, DiDi Express). Also know as 'ridesourcing'.

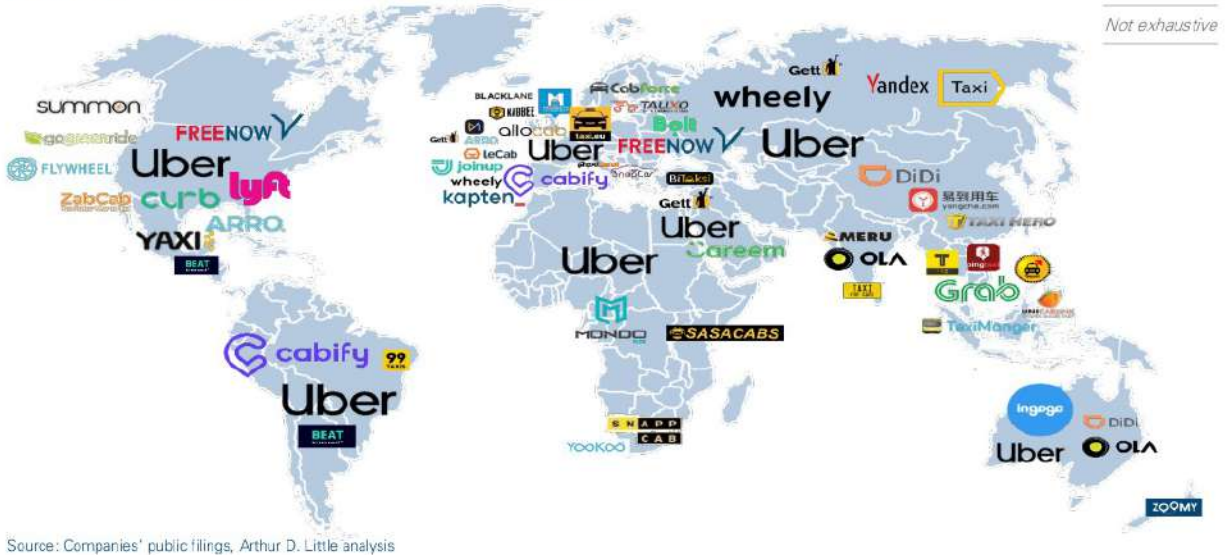
Shared ride-hailing: a rider (or rider party) is allowed to share rides with other riders (or rider parties), and split the fare (e.g. UberPOOL, LyftLine, GrabShare, DiDi Express Pool). Also known as 'ridesharing', 'ridesplitting

Ride-hailing

- Inconsistent terminology used:
  - Popular press calls it 'ridesharing' or 'ride-hailing', etc.
  - Service providers call themselves 'transportation network companies (TNCs)', 'transportation network providers (TNPs)', 'mobility service providers (MSPs)', etc.
  - Researchers use 'Mobility-on-Demand (MoD)', 'ridesourcing', 'ride-hailing', etc.
- In January 2015, the standard was set to officially adopted the term "ride-hailing" to describe the services offered by TNCs (by the Associated Press Stylebook)

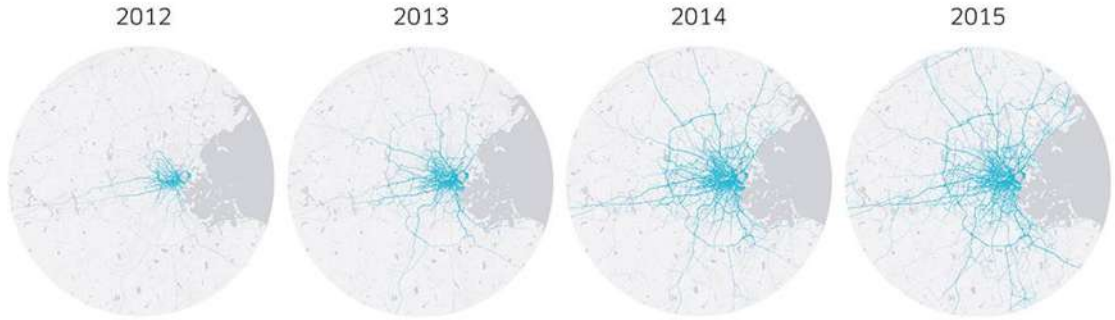
A booming industry

Figure 2: Overview of transport network companies by region

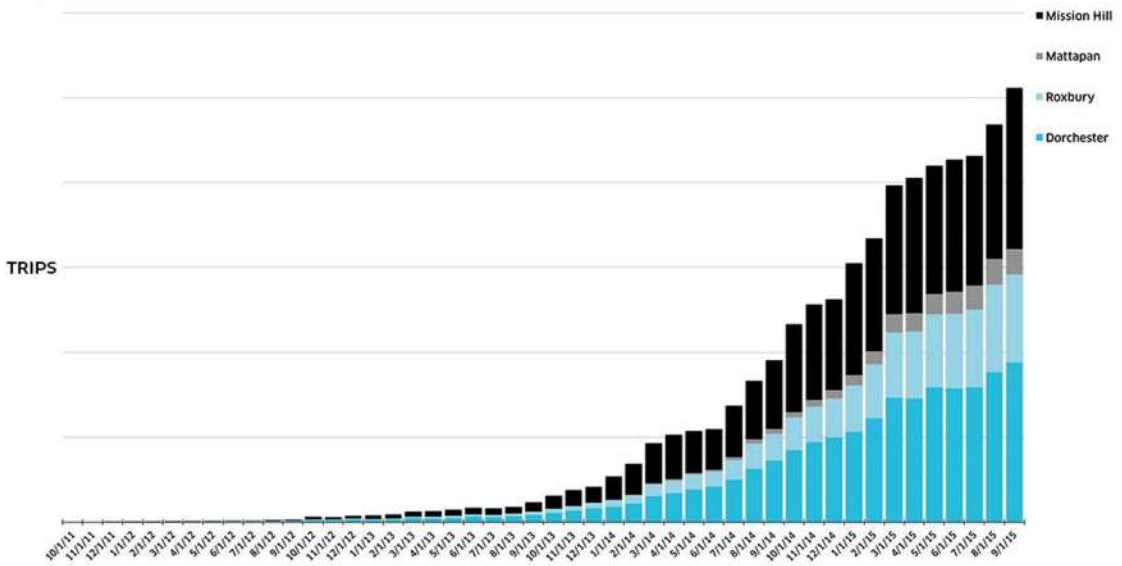


Source: Companies' public filings, Arthur D. Little analysis

Uber trip routes in Boston



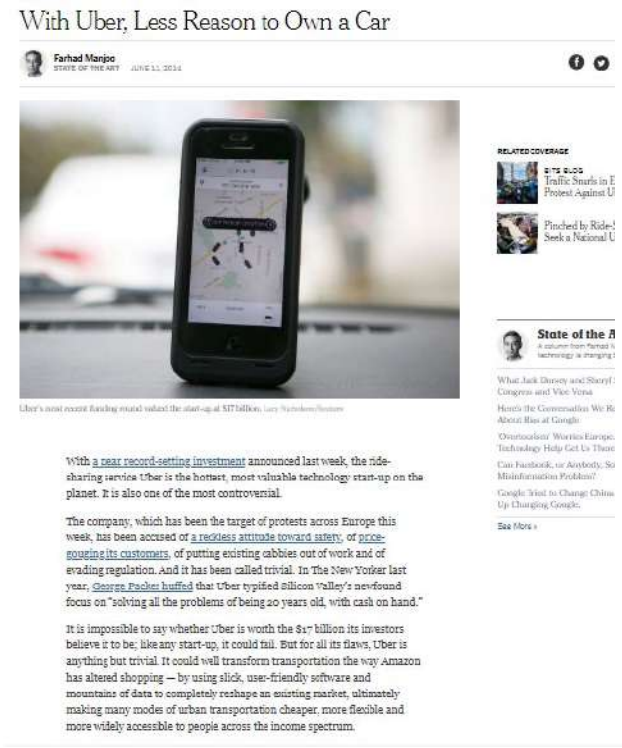
Number of Uber trips in four areas in Boston



(Source: 4 Years Moving Boston, Uber Blog)

Ride-hailing: a solution?

- Ride-hailing' impact on urban mobility is **under intense debate**.



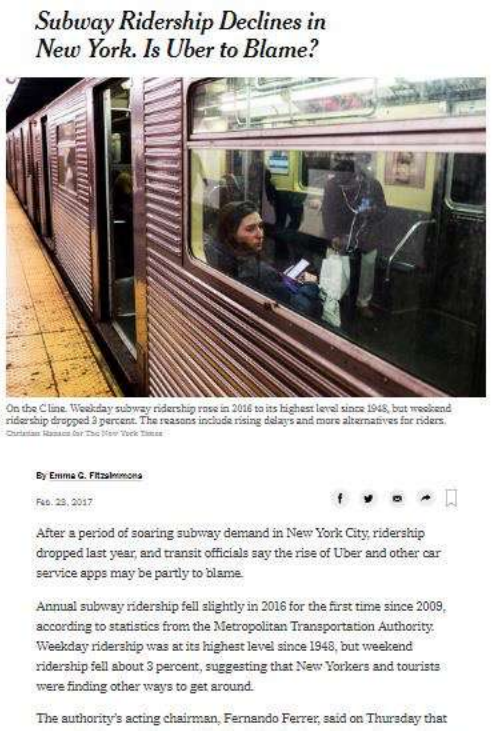
With Uber, Less Reason to Own a Car

Farhad Manjoo

With a near record-setting investment announced last week, the ride-sharing service Uber is the hottest, most valuable technology start-up on the planet. It is also one of the most controversial.

The company, which has been the target of protests across Europe this week, has been accused of a reckless attitude toward safety, of price-gouging its customers, of putting existing cabbies out of work and of evading regulation. And it has been called trivial. In The New Yorker last year, George Packer huffed that Uber typified Silicon Valley's newfound focus on "solving all the problems of being 20 years old, with cash on hand."

It is impossible to say whether Uber is worth the $17 billion its investors believe it to be; like any start-up, it could fail. But for all its flaws, Uber is anything but trivial. It could well transform transportation the way Amazon has altered shopping — by using slick, user-friendly software and mountains of data to completely reshape an existing market, ultimately making many modes of urban transportation cheaper, more flexible and more widely accessible to people across the income spectrum.



Subway Ridership Declines in New York. Is Uber to Blame?

On the C line. Weekday subway ridership rose in 2016 to its highest level since 1948, but weekend ridership dropped 3 percent. The reasons include rising delays and more alternatives for riders.

By Emma G. Fitzsimmons

Feb. 23, 2017

After a period of soaring subway demand in New York City, ridership dropped last year, and transit officials say the rise of Uber and other car service apps may be partly to blame.

Annual subway ridership fell slightly in 2016 for the first time since 2009, according to statistics from the Metropolitan Transportation Authority. Weekday ridership was at its highest level since 1948, but weekend ridership fell about 3 percent, suggesting that New Yorkers and tourists were finding other ways to get around.

The authority's acting chairman, Fernando Ferrer, said on Thursday that

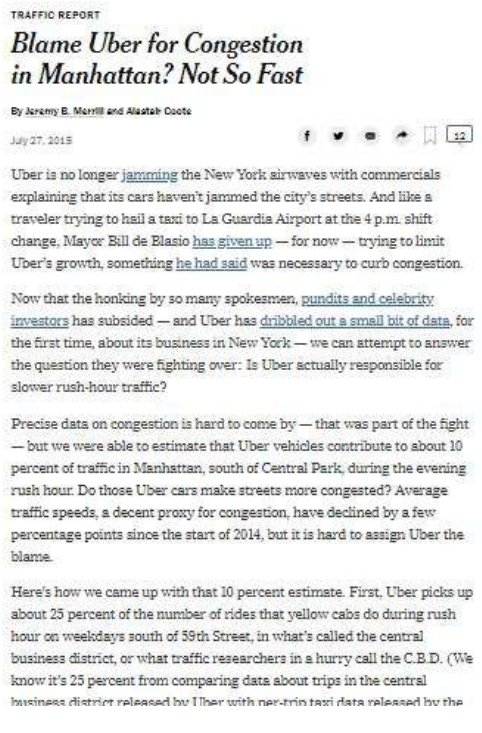
FiveThirtyEight

Politics Sports Science & Health Economics Culture

Is Uber Making NYC Rush-Hour Traffic Worse?

An Uber car. SPENCER PLATT / GETTY IMAGES

Uber has been taking passengers from taxis, one by one, on the busiest streets of Manhattan, as we wrote in October.[1] But is that shift in the city's transportation habits consistent all day long, or are there peak periods when the new ride-for-hire service is adding more trips to the streets than taxis are losing? In other words, is Uber making congestion worse at some hours of



TRAFFIC REPORT

Blame Uber for Congestion in Manhattan? Not So Fast

By Jeremy B. Merrill and Aaastab Coote

July 27, 2015

Uber is no longer jamming the New York airwaves with commercials explaining that its cars haven't jammed the city's streets. And like a traveler trying to hail a taxi to La Guardia Airport at the 4 p.m. shift change, Mayor Bill de Blasio has given up — for now — trying to limit Uber's growth, something he had said was necessary to curb congestion.

Now that the honking by so many spokesmen, pundits and celebrity investors has subsided — and Uber has dribbled out a small bit of data, for the first time, about its business in New York — we can attempt to answer the question they were fighting over: Is Uber actually responsible for slower rush-hour traffic?

Precise data on congestion is hard to come by — that was part of the fight — but we were able to estimate that Uber vehicles contribute to about 10 percent of traffic in Manhattan, south of Central Park, during the evening rush hour. Do those Uber cars make streets more congested? Average traffic speeds, a decent proxy for congestion, have declined by a few percentage points since the start of 2014, but it is hard to assign Uber the blame.

Here's how we came up with that 10 percent estimate. First, Uber picks up about 25 percent of the number of rides that yellow cabs do during rush hour on weekdays south of 59th Street, in what's called the central business district, or what traffic researchers in a hurry call the C.B.D. (We know it's 25 percent from comparing data about trips in the central business district released by Uber with per-trip taxi data released by the

A comprehensive assessment

on the overall net effects of ride-hailing on urban mobility

Previous studies

Impacts of Ride-hailing on Efficiency

- Ride-hailing vs. Taxi
  - Ride-hailing substitutes taxis: satisfies fluctuating demand (Edelman & Geradin, 2016), reduces transaction costs (Rogers, 2015), reduces the uncertainty and anxiety of waiting for a cab (Edelman & Geradin, 2016)…
- Ride-hailing vs. Public Transit
  - Substitution: leads to transit ridership decline (Rayle et al., 2016; Henao, 2017; Gehrke et al., 2018)
  - Complementation: fill in the 'transit desert'; serve as the first-/last-miles (Hall et al., 2017; Williams, 2017)
  - Both substitution and complementation (Jin et al., 2019; Kong et al., 2020; Clewlow and Mishra, 2017)

(continued)

Impacts of Ride-hailing on Efficiency

- Vehicle utilization
  - Higher vehicle occupancy than taxis: driver-rider matching algorithm, surge price, economies of scale (Castiglione et al., 2016; Cramer & Krueger, 2016; Jiang et al., 2018)
  - Reasons? Variations?
- Road congestion
  - Decrease congestion (Li et al., 2016)
  - Increase congestion (Anderson, 2014; Erhardt et al., 2019; Qian et al., 2020)
  - Very subtle impacts (Bialik et al., 2015; Nie, 2017)

Ride-hailing vs. transit

Relationship between ride-hailing and public transit

Is ride-hailing a substitution or complementation for public transit?

[1] **Kong, H.**, Zhang, X.*, & Zhao, J. (2020). How does ridesourcing substitute for public transit? A geospatial perspective in Chengdu, China. *Journal of Transport Geography*, *86*, 102769.
[2] **Kong, H.,** Jin, S. T.*, & Sui, D. Z. (2020). Deciphering the relationship between bikesharing and public transit: Modal substitution, integration, and complementation. Transportation Research Part D: Transport and Environment, 85, 102392.
[3] Jin, S. T.†, **Kong, H.†***, & Sui, D. Z. (2019). Uber, public transit, and urban transportation equity: a case study in New York City. *The Professional Geographer*, 1-16
[4] Meredith-Karam, P., **Kong, H.***, & Zhao, J. The Relationship Between Ridehailing and Public Transit in Chicago: An analytical approach and application to the COVID-19 Pandemic. *Journal of Transport Geography. (Under Review)*

Research background

Ride-hailing:

- Compete with public transit, result in transit ridership decline?
- Complement public transit, connect riders to transit stations?

?

Ride-hailing vs. public transit? – unclear

Case study in Chengdu

Case study: Chengdu, China

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

How does ridesourcing substitute for public transit? A geospatial perspective in Chengdu, China

Hui Kong[a,b], Xiaohu Zhang[b,*], Jinhua Zhao[b]

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DiDi
(the largest Ride-hailing company in China)

vs.

Public transit

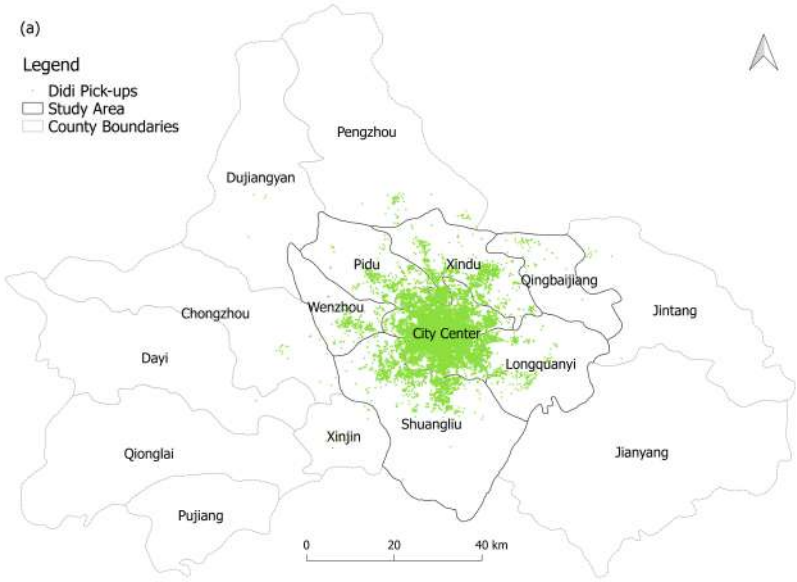
Kong, H., Zhang, X.*, & Zhao, J. How does ridesourcing substitute public transit? A geospatial perspective. *Journal of Transport Geography* (under review)

Data

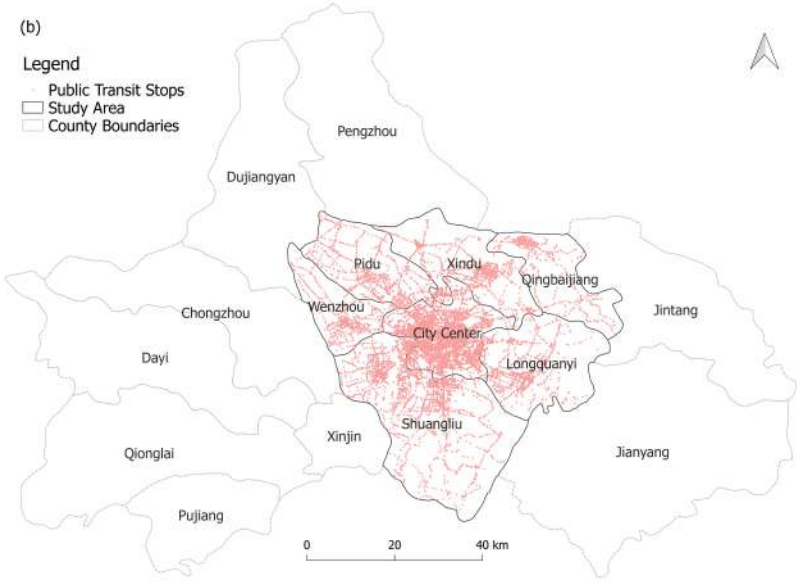
1) DiDi OD data
   - time, coordinates
   - 1 day, 181,172 records

Do not consider sharing trips!

2) Public transit stops and schedule



DiDi Pick-ups



transit stops

Our contributions

1. New definition

2. Original methods

Definition in economics:

- Elasticity – one number
- dry, aggregate

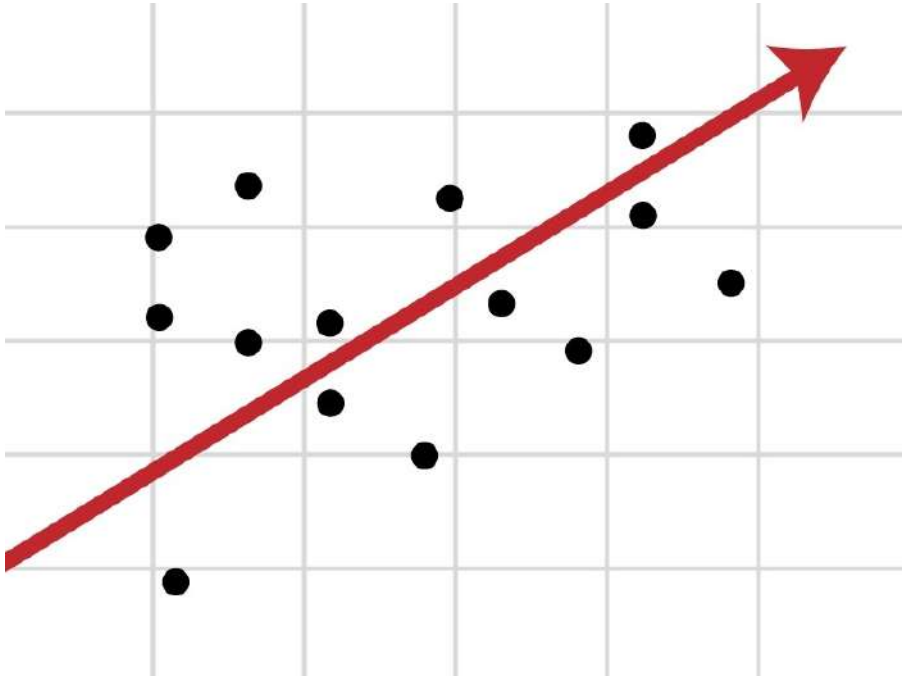
We want to differentiate the relationship of each trip!

Previous studies - methods

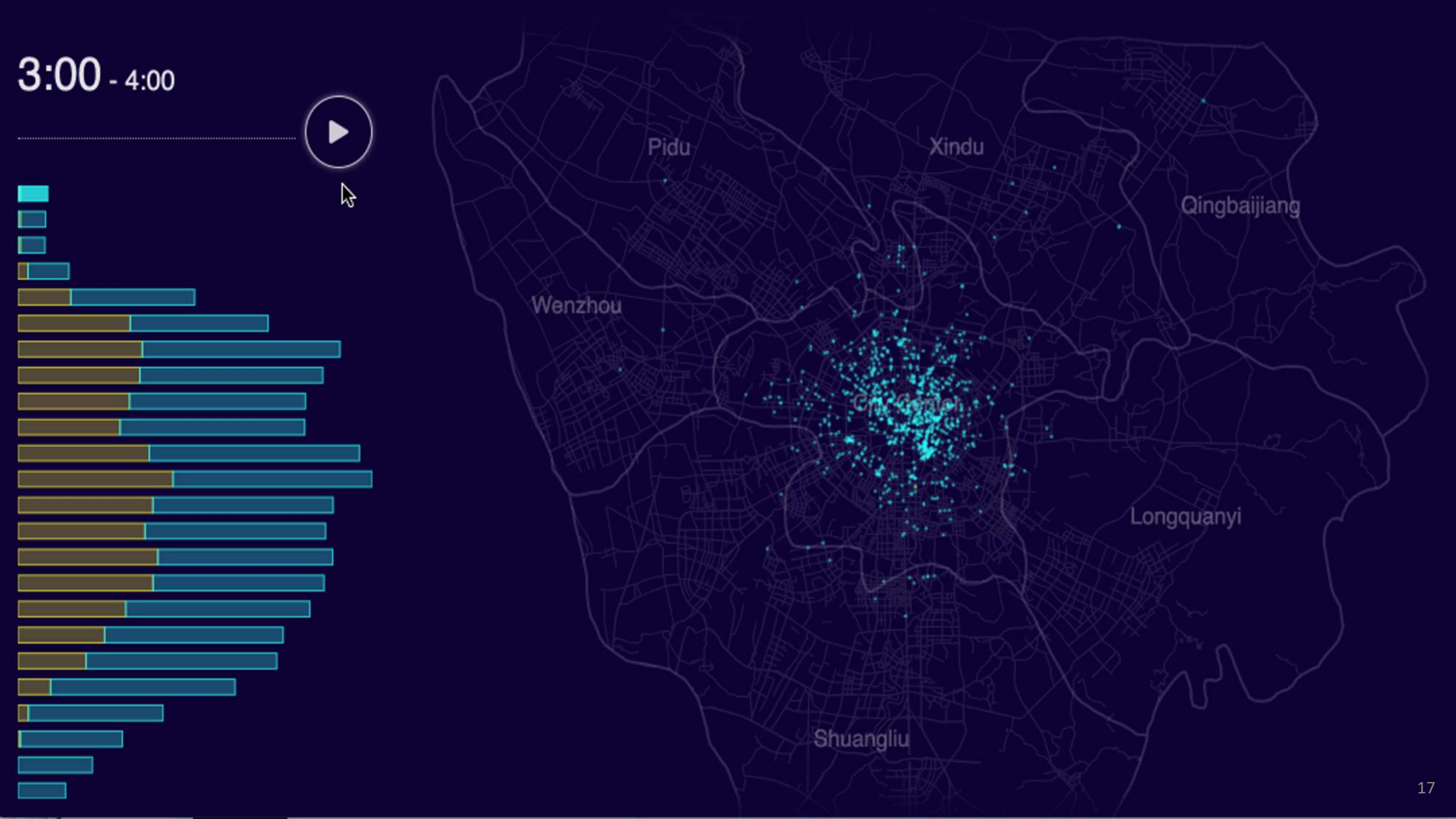
#1 Surveys

- Small sample
- biased

#2 Statistical Models



- aggregate


3:00 - 4:00
Pidu
Xindu
Qingbaijiang
Wenzhou
Longquanyi
Shuangliu

Complement Effect

The square filled by ■ indicates that all the Didi rides in this area are complement, not substitute. Its spacial distribution shows this complement effect is more in suburban areas as public transit has poorer coverage.

Planning/policy implications

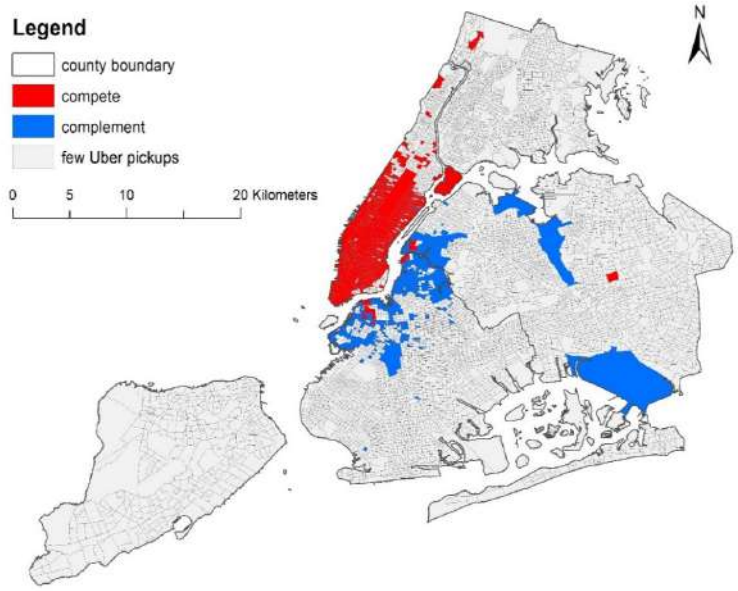
shared mobility fee

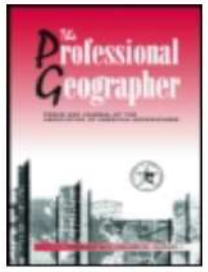
pinpoint OD pairs

spatial quota

for other cities…

New York City





The Professional Geographer

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Uber, Public Transit, and Urban Transportation Equity: A Case Study in New York City

Scarlett T. Jin, Hui Kong & Daniel Z. Sui

To cite this article: Scarlett T. Jin, Hui Kong & Daniel Z. Sui (2019): Uber, Public Transit, and Urban Transportation Equity: A Case Study in New York City, The Professional Geographer

City center: substitution (**red** areas)
Surrounding areas: complement (**blue** areas)

Jin, S. T.†, **Kong, H.†***, & Sui, D. Z. (2019). Uber, public transit, and urban transportation equity: a case study in New York City. *The Professional Geographer*, 1-16

For other modes

bike-sharing vs. transit

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Deciphering the relationship between bikesharing and public transit: Modal substitution, integration, and complementation

Hui Kong[a,1], Scarlett T. Jin[b,*,1], Daniel Z. Sui[c]

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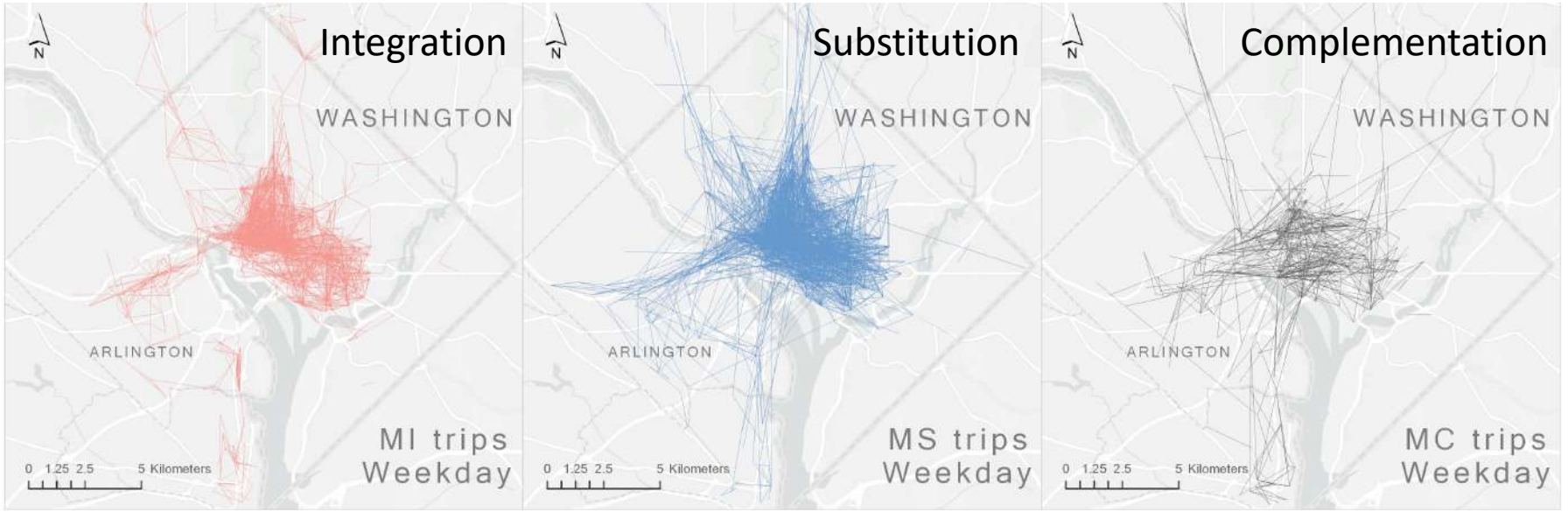


Jin, S. T.†, **Kong, H.†***, & Sui, D. Z. (2019). Uber, public transit, and urban transportation equity: a case study in New York City. *The Professional Geographer*, 1-16

Kong, H., Jin, S. T.*, & Sui, D. Z. Decipher the relationship between bikesharing and public transit: Modal substitution, integration, or complementation? *Transportation Research Part D.* (under review)

First- and last-mile?

Ride-hailing serves as the first-/last-mile?

- Chengdu: <= 5%
- Chicago: 2.89% - 3.91%

Only a small proportion!

Bikesharing serves as the first-/last-mile?

- Boston: 25.2% - 39.1%
- Chicago: 28.8% - 47.0%
- Washington DC: 34.7% - 52.5%
- NYC: 32.4% - 48.2%

Vehicle Occupancy Rate

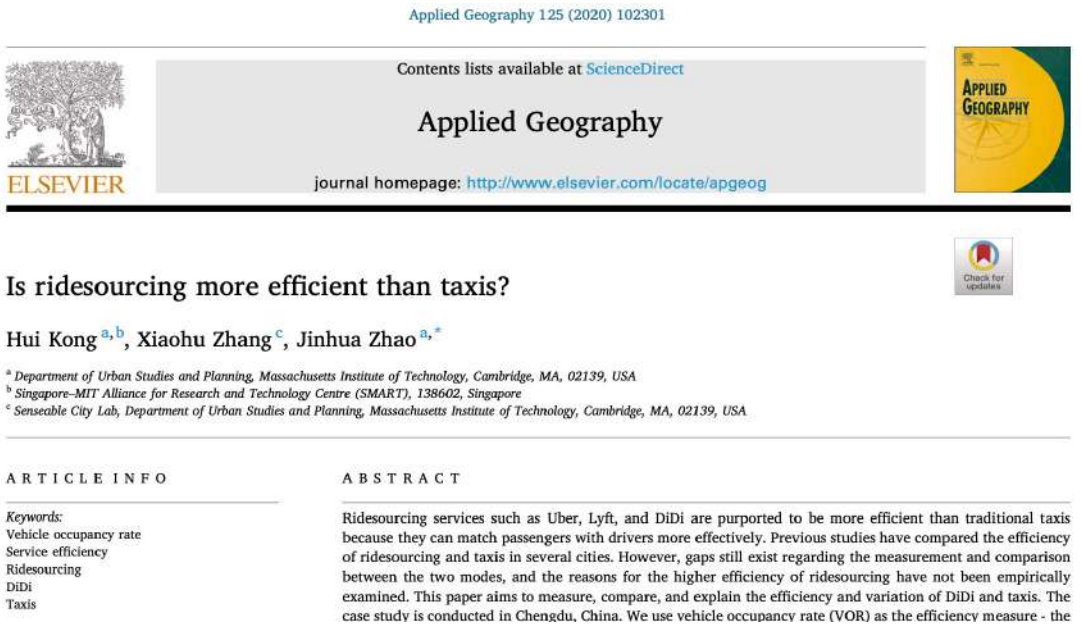
Comparison of Vehicle Occupancy Rate (VOR) between ride-hailing and taxis

Vehicle Occupancy Rate (VOR): percentage of time that a vehicle is occupied

Ride-hailing is supposed to have higher efficiency

This study - Chengdu, China

- measure the VORs of DiDi and taxi
- compare the VORs between DiDi and Taxi



Applied Geography 125 (2020) 102301

Contents lists available at ScienceDirect

Applied Geography

journal homepage: http://www.elsevier.com/locate/apgeog

Is ridesourcing more efficient than taxis?

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ARTICLE INFO

Keywords:
Vehicle occupancy rate
Service efficiency
Ridesourcing
DiDi
Taxis

ABSTRACT

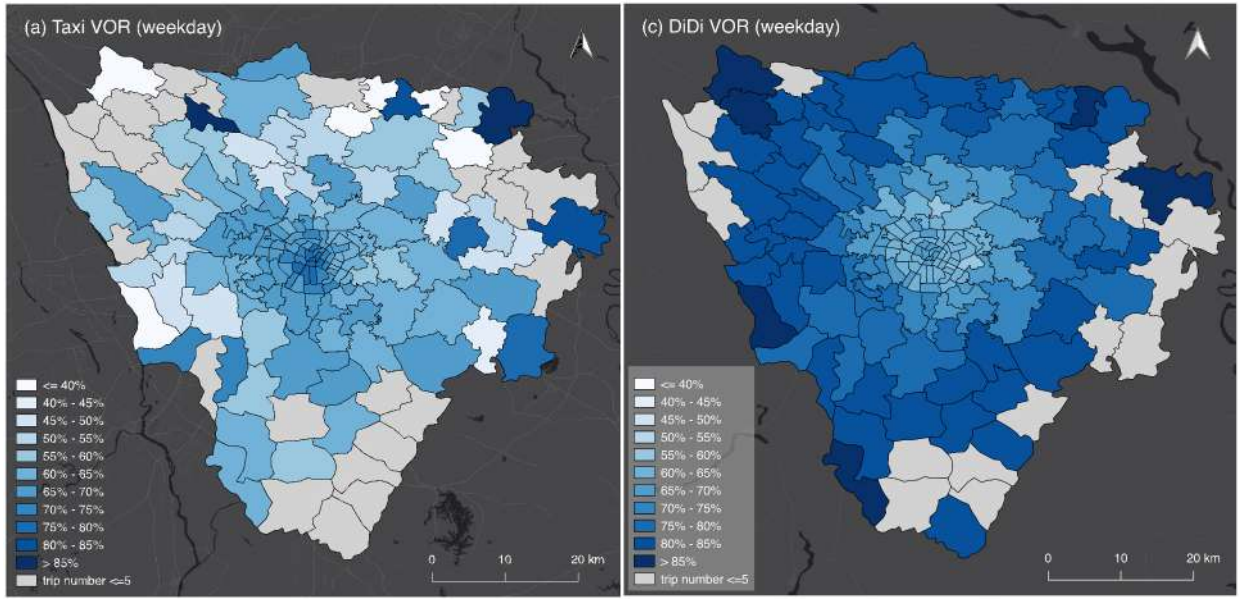
Ridesourcing services such as Uber, Lyft, and DiDi are purported to be more efficient than traditional taxis because they can match passengers with drivers more effectively. Previous studies have compared the efficiency of ridesourcing and taxis in several cities. However, gaps still exist regarding the measurement and comparison between the two modes, and the reasons for the higher efficiency of ridesourcing have not been empirically examined. This paper aims to measure, compare, and explain the efficiency and variation of DiDi and taxis. The case study is conducted in Chengdu, China. We use vehicle occupancy rate (VOR) as the efficiency measure - the

Kong, H., Zhang, X., & Zhao, J.* (2020). Is ridesourcing more efficient than taxis?. *Applied Geography*, *125*, 102301.

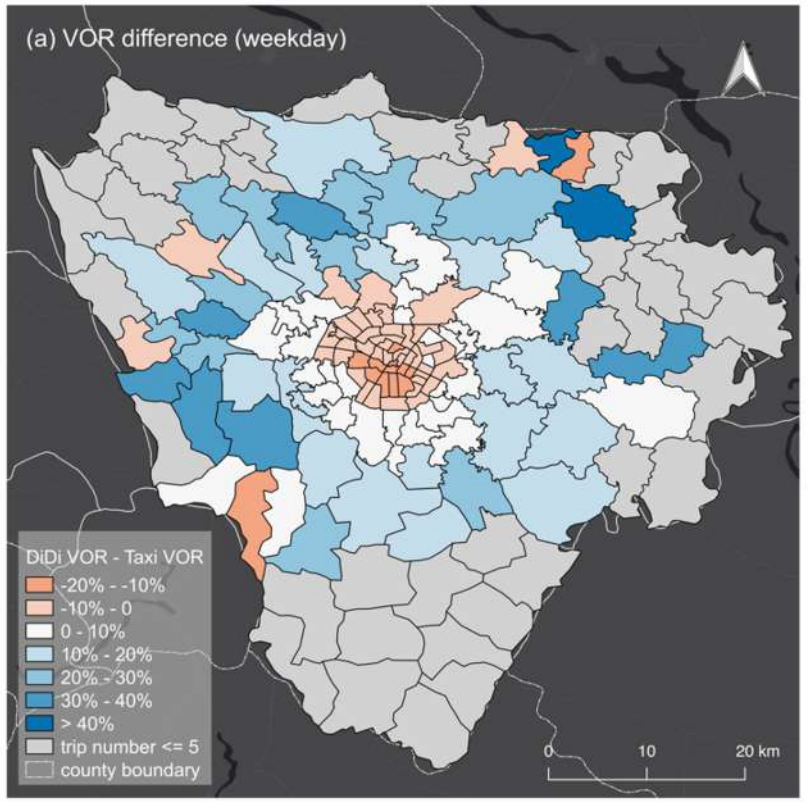
Comparison

Taxi vs. DiDi

- Overall VOR: shared mobility is more efficient
- Different patterns across space



Spatial patterns



VOR difference (DiDi VOR – taxi VOR)

Why? – population density

Policy/planning implications

Why?

- Low density: matching algorithm has advantages
- High density: street-hailing may be more efficient

What actions to take?

- Coordinate taxi and DiDi to achieve system efficiency
- Improve DiDi algorithm in high-density area

Previous studies

Impacts of Ride-hailing on Equity

- User profile
  - Younger, better-educated, and more affluent individuals are more likely to be ride-hailing users (McGrath, 2015; Rayle et al., 2016; A. Smith, 2016; Clewlow & Mishra, 2018)
  - Who are enjoying this service? Who are excluded from it?
- "Digital divide"
  - Unequal access to Information and Communication Technology (ICT) and the requisite skills to use relevant services
  - Ride-hailing highly relies on the use of smartphones and credit cards (Demirgüç-Kunt et al., 2015; Poushter, 2017)

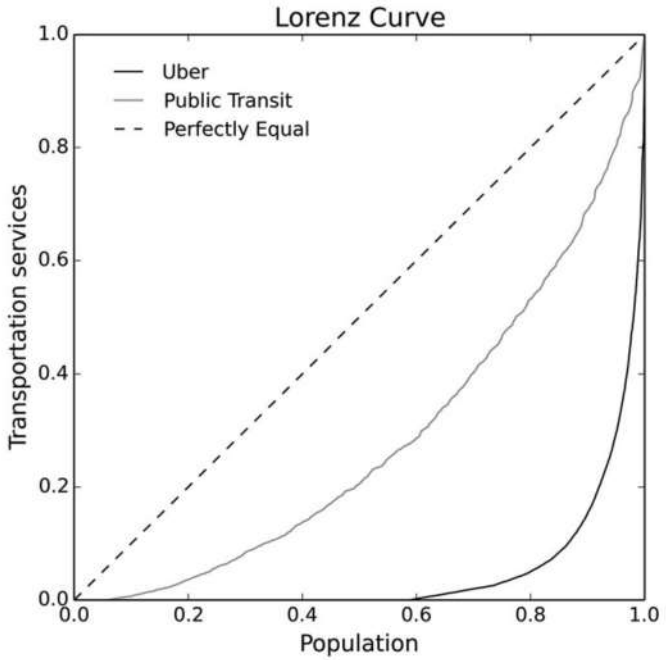
(continued)

Impacts of Ride-hailing on Equity

- Discrimination
  - Racial and gender discrimination (Ge et al., 2016; Moody et al., 2019; Middleton & Zhao, 2019)
  - How ride-hailing serves people with disabilities (Cochran & Chatman, 2021)
- The nature of on-demand work
  - Compensation of on-demand work (Hall & Krueger, 2015; Shokoohyar, 2018)
  - Flexible working schedules? (Chen and Sheldon, 2015; Hall & Krueger, 2015; Cockayne, 2016; Glöss et al., 2016)

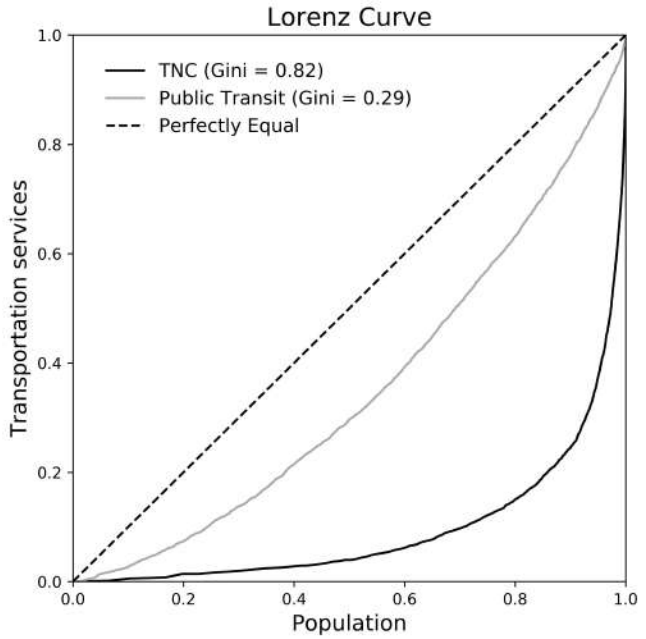
Equity of distribution?

Transportation Gini Coefficient



NYC

- Uber：0.90
- Public Transit：0.67



Chicago

- TNCs：0.82
- Public Transit：0.29

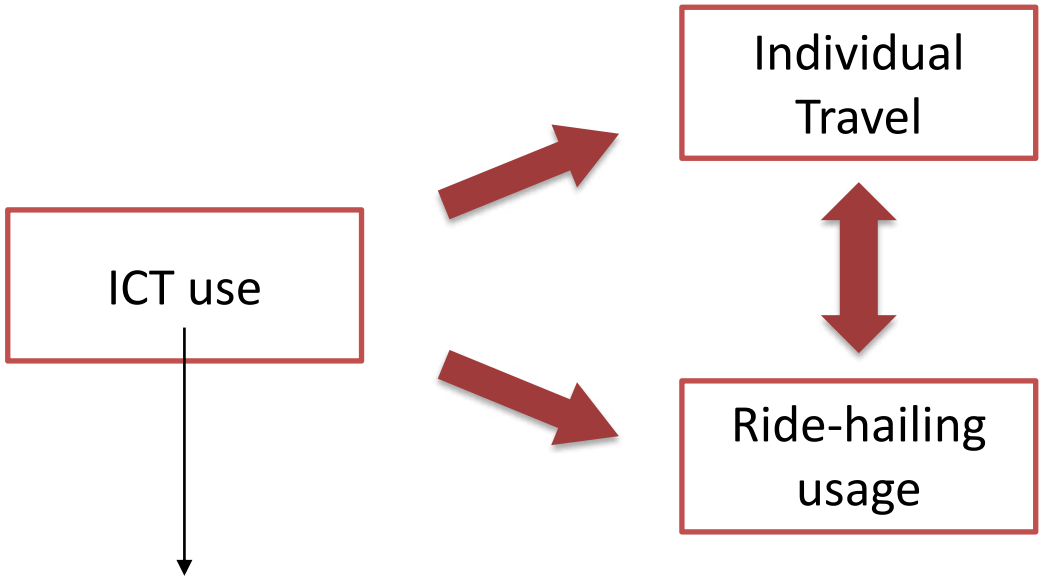
The distribution of ride-hailing among population is highly unequal!

Jin, S. T.†, **Kong, H.**†*, & Sui, D. Z. (2019). Uber, public transit, and urban transportation equity: a case study in New York City. *The Professional Geographer*, 1-16

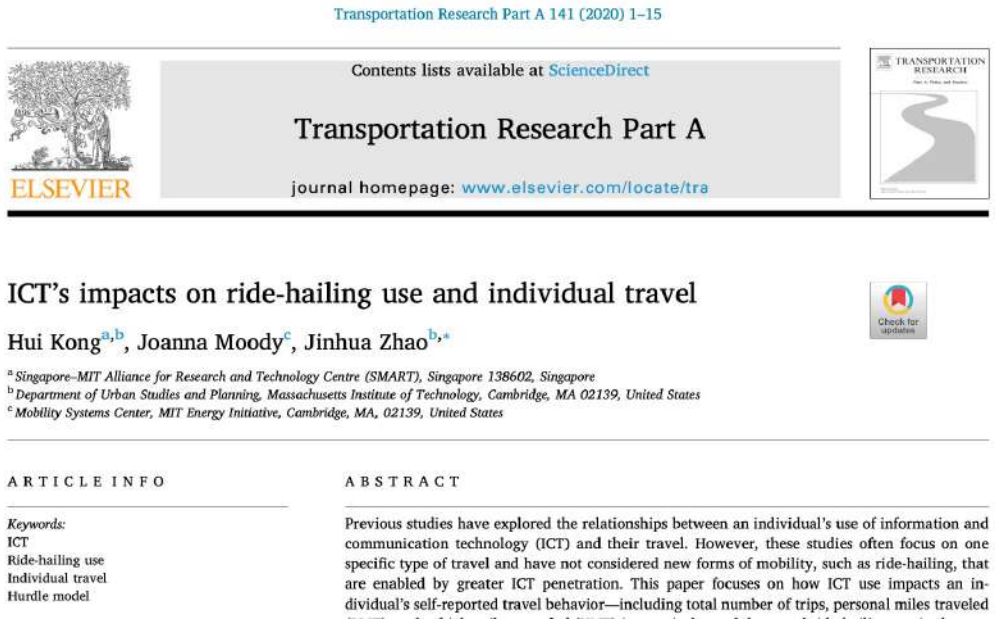
Digital divide

ICT's Impacts on ride-hailing usage and individual travel

In the research on ICT and individual travel, new forms of mobility (e.g. ride-hailing) have not been considered



ICT: Information and Communication Technology



Transportation Research Part A 141 (2020) 1–15

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

ELSEVIER

ICT's impacts on ride-hailing use and individual travel

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ARTICLE INFO

Keywords:
ICT
Ride-hailing use
Individual travel
Hurdle model

ABSTRACT

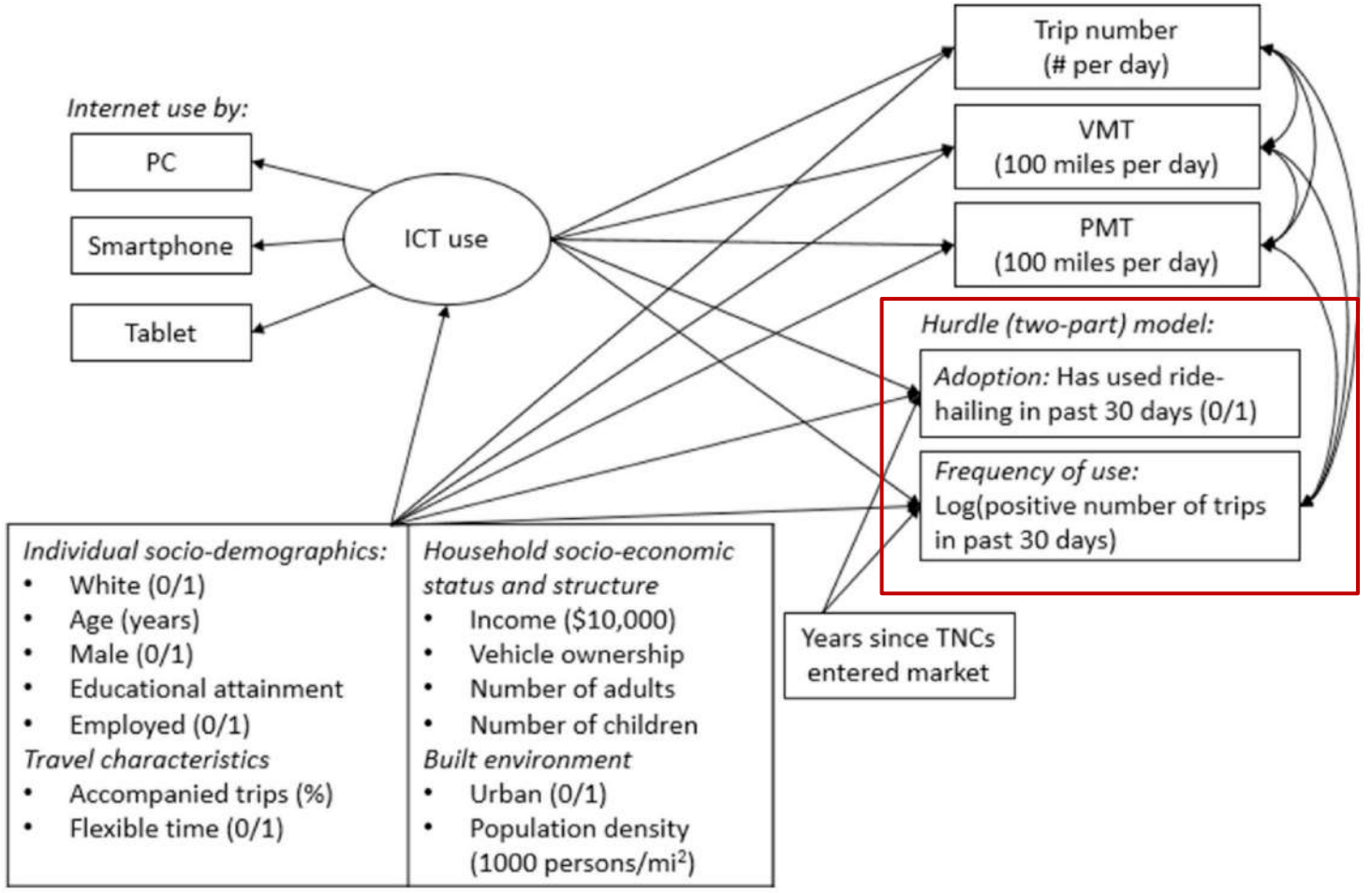
Previous studies have explored the relationships between an individual's use of information and communication technology (ICT) and their travel. However, these studies often focus on one specific type of travel and have not considered new forms of mobility, such as ride-hailing, that are enabled by greater ICT penetration. This paper focuses on how ICT use impacts an individual's self-reported travel behavior—including total number of trips, personal miles traveled

Kong, H., Moody, J., & Zhao, J. *(2020). ICT's impacts on ride-hailing use and individual travel. *Transportation Research Part A: Policy and Practice*, 141, 1-15.

Methods

Data: NHTS 2017 (National Household Travel Survey)

Model: Structure Equation Model (SEM)



Hurdle Estimation

Fig. 1. Path diagram for the SEM.

Results

	Est.
Number of trips on a typical travel day	0.010
PMT (100 mi) on a typical travel day	0.027***
VMT (100 mi) on a typical travel day	0.034***
Ride-hailing adoption (Have used ride-hailing app in the past 30 days)	0.511***
Ride-hailing usage (Frequency of ride-hailing use in the past 30 days)	0.025

- ICT use is much more strongly related to ride-hailing adoption than individual mobility in general
  - ICT is a strong predictor for individual ride-hailing adoption
  - importance of including ride-hailing into the discussions about ICT's impacts on individual travel
  - Existence of 'digital divide'

Previous studies

Impacts of Ride-hailing on Sustainability

- Private car ownership
  - Ride-hailing is assumed to reduce private car ownership as it provides an alternative to owning a car
  - Surveys found that a large proportion of ride-hailing users didn't change their private car ownership (Rayle et al., 2016; Clewlow and Mishra, 2017)
  - Car ownership has symbolic significance beyond its functional purpose (Zhao & Zhao, 2018; Moody & Zhao, 2020)
  - Impacts of ride-hailing on private car ownership is a long-term effect

Previous studies

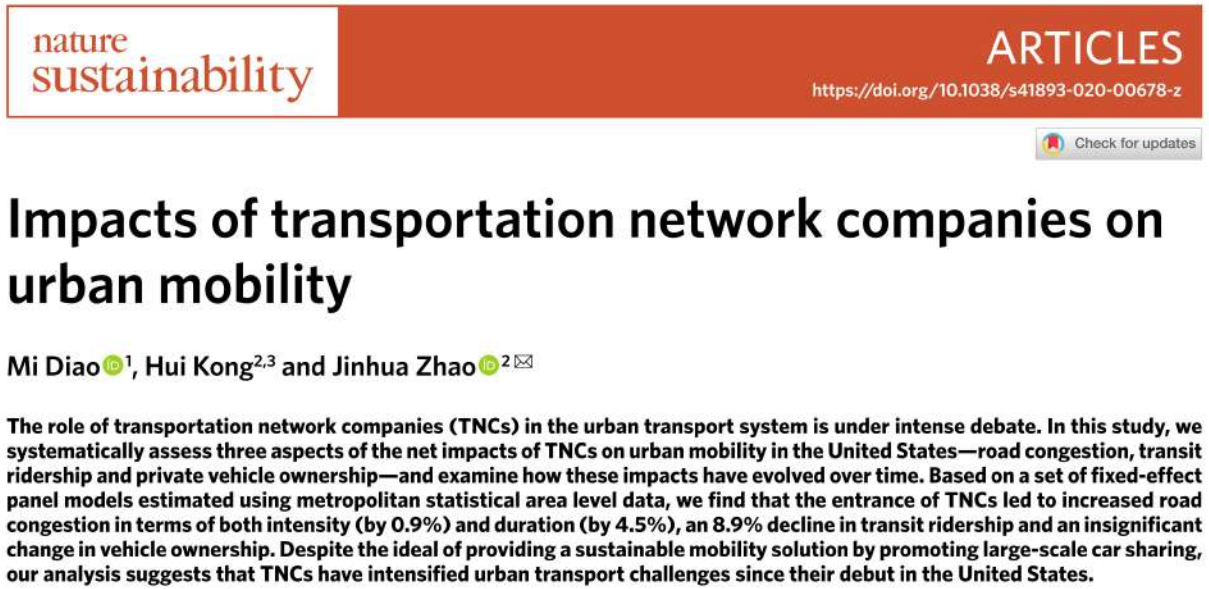
Impacts of Ride-hailing on Sustainability

- Energy consumption and greenhouse gas (GHG) emissions
  - Ride-hailing is expected to reduce Vehicle Miles Travelled (Henao, 2017), reduce deadheading miles (Cramer & Krueger, 2016)
  - Hard to measure: How to measure the VMT when the driver is logging off the apps? How to account for different forms of modal shift?
  - Rebound effect will induce travel and offset the predicted environmental benefits (Sorrell, 2009; Rayle et al., 2016; Schor, 2016; Henao, 2017)

Impacts of TNCs

Impacts of ride-hailing on urban mobility

- Systematically examine how TNCs have changed urban mobility in the United States, as measured by
  - Car ownership
  - Public transit (PT) ridership
  - Congestion level



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ARTICLES

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Check for updates

Impacts of transportation network companies on urban mobility

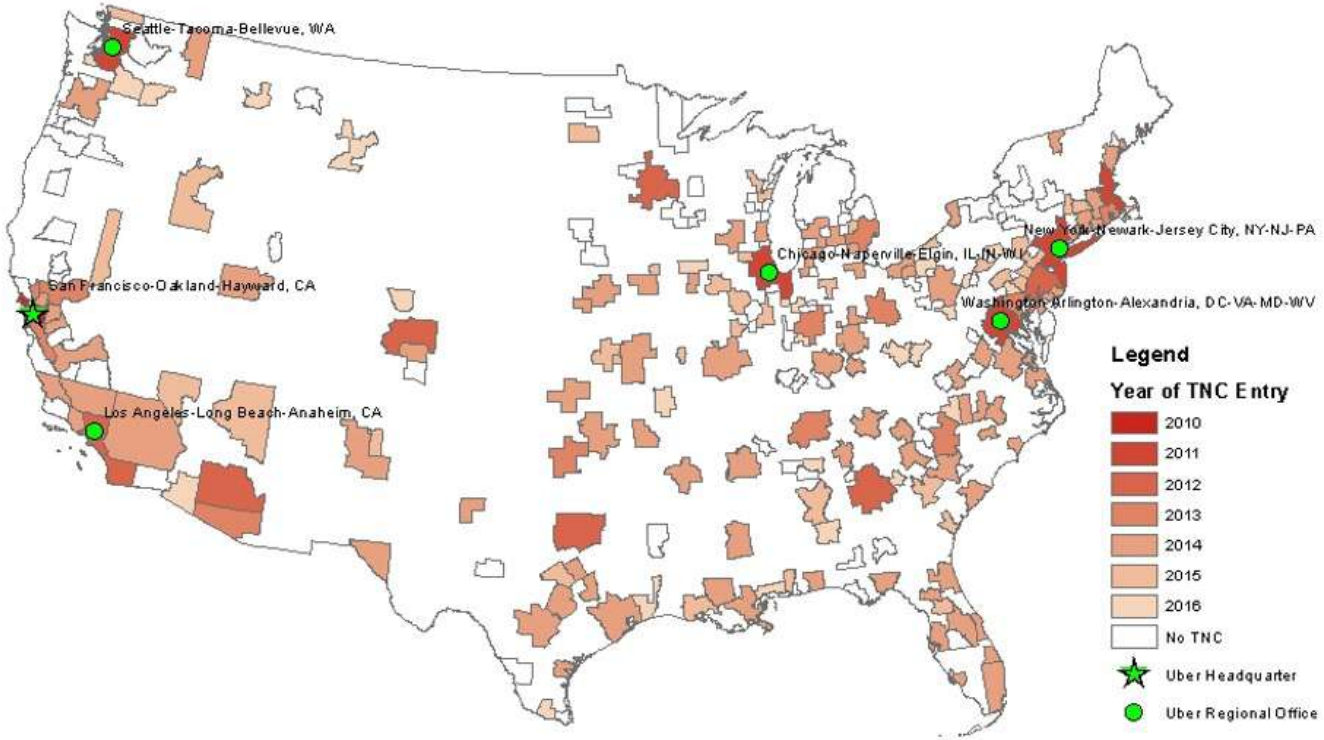
Mi Diao[1], Hui Kong[2,3] and Jinhua Zhao[2]✉

The role of transportation network companies (TNCs) in the urban transport system is under intense debate. In this study, we systematically assess three aspects of the net impacts of TNCs on urban mobility in the United States—road congestion, transit ridership and private vehicle ownership—and examine how these impacts have evolved over time. Based on a set of fixed-effect panel models estimated using metropolitan statistical area level data, we find that the entrance of TNCs led to increased road congestion in terms of both intensity (by 0.9%) and duration (by 4.5%), an 8.9% decline in transit ridership and an insignificant change in vehicle ownership. Despite the ideal of providing a sustainable mobility solution by promoting large-scale car sharing, our analysis suggests that TNCs have intensified urban transport challenges since their debut in the United States.

Diao, M., **Kong, H.**, & Zhao, J.* (2021). Impacts of transportation network companies on urban mobility. *Nature Sustainability*, 1-7.

Study area

Examine the impacts of TNC entry into MSAs on urban mobility measures



MSAs in the US by the year of TNC entry

Methods: panel regression

We calibrate two fixed-effect panel data models

- Model 1: base model on TNC entry

time fixed effects

private car ownership/PT ridership/congestion level

$$y_{it} = \alpha + \beta \times TNC_{it} + r \times Controls_{it} + \theta_i + \tau_t + \epsilon_{it}$$

MSA fixed effects

$$TNC_{it} = \begin{cases} 1: \text{there is TNC service in MSA } i \text{ at time } t \\ 0: \text{otherwise} \end{cases}$$

- Model 2:
  - TNC effect over time
  - The entry of the second TNC operator

$$y_{it} = \alpha + \beta_0 \times TNC_Year0_{it} + \beta_1 \times TNC_Year1_{it} + \cdots + \beta_n \times TNC_{YearN_{it}} + \delta_{it} \times TNC2_{it} + r \times Controls_{it} + \theta_i + \tau_t + \epsilon_{it}$$

TNC_YearN_{it}: Dummy variable indicating *N* years after the entry of TNC in MSA *i*

Dummy variables indicating presence of second TNCs

Robustness Checks

- Robustness Check #1: What if TNCs determine when to enter an MSA based on its mobility patterns?
  - IV (Instrumental Variable) regression
  - Use “distance to TNC hubs” as the Instrument
- Robustness Check #2: What if we include all the MSAs?
  - 174 MSAs with TNC operation in 2016 → include non-TNC MSAs
- The main findings still hold after the two robustness checks

Impacts of TNCs on Car Ownership

- On average, TNC entry has insignificant effect on car ownership.
- We interact TNC with a dummy variable indicating top 10 transit MSAs, and find TNC can reduce car ownership in PT-friendly MSAs by 1% relative to other MSAs.

	(1) Model 1		(2) Model 1 + top 10 transit	
	Estimate	t-stat.	Estimate	t-stat.
Constant	0.4244	42.622***	0.4172	41.615***
TNC	-0.0003	-0.239	0.0011	0.963
TNC * Top10 Transit			-0.0103	-4.620***
Control variables	Yes		Yes	
MSA fixed effect	Yes		Yes	
Year fixed effect	Yes		Yes	

Significance codes: '***' 0.01 '**' 0.05 '*' 0.1

Impacts of TNCs on PT ridership

- On average, the entry of TNC can reduce PT ridership by 8.9%.
- The impact of TNC increases in the first 3 years and stabilizes thereafter.
- The entry of the second TNC operator has a negative effect of 2.1%.

	(1) Model 1		(2) Model 2	
	Estimate	t-stat.	Estimate	t-stat.
Constant	12.7518	172.387***	12.7300	171.004***
TNC	-0.0890	-11.597***		
Within 1 year of TNC entry			-0.0768	-9.084***
Within 1-2 year of TNC entry			-0.1216	-10.812***
Within 2-3 year of TNC entry			-0.1598	-10.256***
Within 3-4 year of TNC entry			-0.1583	-6.852***
Beyond 4 year of TNC entry			-0.1628	-5.384***
Two TNC operators			-0.0212	-2.243**
Control variables	Yes		Yes	
MSA fixed effect	Yes		Yes	
Month fixed effect	Yes		Yes	

Increasing magnitude

Signif. codes: '***' 0.01 '**' 0.05 '*' 0.5

Impacts of TNCs on Congestion

- Two measures of congestion:
  - Travel Time Index (TTI): the ratio of the peak-period travel time to the free-flow travel time
  - Congested Hours (CH): the average number of hours in which road sections are congested
- On average, TNC can increase the level of congestion as measured by TTI and CH.

	Log(TTI)		Log(CH)	
	(1) Model 1		(3) Model 1	
	Estimate	t-stat.	Estimate	t-stat.
(Intercept)	-0.7110	-7.349***	-2.6150	-4.969***
TNC	0.0089	3.400***	0.0449	2.966**
Control variables	Yes		Yes	
MSA fixed effect	Yes		Yes	
Month fixed effect	Yes		Yes	

Signif. codes: '***' 0.01 '**' 0.05 '*' 0.1

Main Findings

- Ride-hailing has intensified urban transport challenges in the US, rather than relieving them.
  - Ride-hailing's effect on private vehicle ownership is insignificant
  - Ride-hailing led to a significant decline in PT ridership
  - Ride-hailing increased congestion, mainly through the extended duration and slightly through the increased intensity.
- Although mathematical models show the potential benefits of shared mobility, this study suggests that translating this potential into actual gains is much more complicated in the real world.

Future urban mobility

Shared mobility: a significant component in multi-modal transportation

- A feeder of public transit
- More efficient vehicle utilization
- Encourages walking, cycling, scootering
- Provides service for disabled/elderly...

THANK YOU

Q&A

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